Engineering Library

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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See page 101, Feb. 8. 6455

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CARDIFF WAREHOUSE—132, BUTE ST.
BIRMINGHAM WAREHOUSES—NILE STREET, SHEEPSCOTE STREET, and 10, COLESHILL STREET.
See Advertisement page 28. 6463

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FROM 50 TO 600 YARDS PER HOUR.
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See Advertisement page 27, Jan. 18. 3402

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Three Sizes, Delivery from Stock.
NEW CAPSTANS, 1¼ in. through the wire feed.
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Centrifugals.
Pott, **C**assels & **W**illiamson,
MOTHERWELL, SCOTLAND. 6246
See half-page Advertisement page 32, Jan. 25.

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The Manchester Steam Users' Association.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.

Chief Engineer: C. B. Stromeyer, M.I.C.E.

Founded 1854 by Sir William Fairbairn.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 5884

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Established 1892.

Foremen, Managers and Employers connected with the Engineering Industry.

MONTHLY MEETINGS are held at the Cannon Street Hotel, E.C.

Membership is not confined to residents in London

Secretary:

JAMES HARRINGTON, K 6

85, Salisbury Road, Harrow, Middlesex.

In the High Court of Justice. 1918 A. 94.
Chancery Division.
Mr. Justice Younger.
In the Matter of Algerian Oilfields, Limited and Reduced,
and
In the Matter of the Companies (Consolidation) Act, 1908.

Notice is Hereby Given that

a Petition presented to the High Court of Justice, Chancery Division, on the 18th January, 1918, for confirming a Special Resolution reducing the capital of the above-named Company from £500,000, divided into 500,000 shares of £1 each (of which 304,904 shares have been issued and are outstanding and fully paid, 63,688 shares have been forfeited for non-payment of calls, and 131,408 shares have never been issued), to £235,580 5s., divided into 304,904 shares of 2s. each, and 195,096 shares of £1 each, and that such reduction be effected by cancelling capital, which has been lost or is unrepresented by available assets, to the extent of 18s. a share upon each of the 304,904 shares which have been issued and are outstanding, and that on such reduction taking effect each of the 63,688 shares of the Company which have been forfeited and the 131,408 shares which have not been issued be subdivided into ten shares of 2s. each, is directed to be heard before His Lordship Mr. Justice Younger at the Royal Courts of Justice, Strand, London, on Tuesday, the 19th day of February, 1918, when any Creditor or Shareholder of the Company desiring to oppose the making of an Order for the reduction of the Capital of the said Company under the above Act, should appear at the time of hearing, by himself or his Counsel, for that purpose, and a copy of the Petition will be furnished to any Creditor or Shareholder of the Company requiring the same by the undersigned Solicitors on payment of the regulated charges for the same.

Dated this 5th day of February, 1918.

H. T. WATKIN-WILLIAMS,
Master of the Supreme Court.

MACKRELL, MATON, GODLEE & QUINCEY,
21, Cannon Street, E.C., Solicitors for the said Petitioners. K 337

Defence of the Realm Regulations.
Withdrawal of Machine Tool Permits issued under Regulation 30a.

Notice is Hereby Given

that the Permits formerly held by the following Persons, Firms and Companies authorising them to buy, sell or deal in Machine Tools have been withdrawn:—

Permit No.	Date Withdrawn.	Name of Firm.
288	19.12.16	J. R. Kelly & Co., Ltd., 3, Bridge End, Leeds.
299	30.7.17	Lawton Bros., 70, Barton Arcade, Manchester.
335	3.1.17	George Mann & Co., Hunslet, Leeds.
336	26.7.17	Martin Bros., 33-5, Bridge Street, Manchester.
424	20.12.16	Charles Purden, Ltd., 46, Lancaster Street, Manchester.
467	13.8.17	W. Allan Smethurst, Dilsbury, Manchester.
534	19.12.16	Universal Machinery Co., Hunslet, Leeds.
809	10.12.17	Litton Machine Tool Co., 373-9, Old Street, E.C.
492	17.1.18	Storey Machine Tool Co., Pomeroy Street, New Cross, S.E.

It should be understood that the effect of the withdrawal of the permits referred to is that no person is permitted to purchase or negotiate a purchase from any of the foregoing persons, firms or companies of any machine tool or machinery driven by power and suitable for use in cutting, stamping or working metal as specified in the Order of the Minister of Munitions, dated the 28th August, 1916.

Certain of the foregoing persons, firms and companies have been authorised to dispose of their existing stocks, subject to the approval of the transaction by or on behalf of the Minister of Munitions.

It is, therefore, incumbent upon an intending purchaser to ascertain by direct enquiry from the Machine Tool Department, Ministry of Munitions, Charing Cross Buildings, Embankment, W.C. 2, whether it is permissible to purchase a Machine Tool from any of the above-mentioned persons, firms or companies. K 327

Correspondence Courses for B.Sc., A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E.

Tuition in separate subjects, if desired.

Thorough, rapid, efficient coaching under my personal supervision.

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Tuition. Also Postal Courses in Mechanical Engineering, Aircraft Design and Mathematics.—PENNINGTONS, 264, Oxford Road, Manchester.

TENDERS.

COUNTY BOROUGH OF BELFAST.

WORKS DEPARTMENT.

TENDERS FOR STORES, WORK AND UNIFORM CLOTHING.

The Works Committee are prepared to receive

Tenders for the Supply of the

following Stores, Work and Uniform Clothing, for the year, commencing 1st April, 1918:—

Earthenware Sewer Piper.	Shovels, Spades, Graipes and Buckets.
Timber.	Scavenging Brushes.
Slates:	Glazed Bricks.
Hardwood.	Artificial Flags.
Iron Castings.	Lime.
Plumbers' Work.	Pitch, Felt, Tar, &c.
Nails, &c.	Sea Sand, Sea Gravel &
Iron and Steel.	Lough Neagh Sand.
Paints, Oils, &c.	Cement.
Glazing.	Uniform Clothing and
Mill Furnishings.	Hats.

Forms of Tender and particulars may be obtained at the office of the Superintendent of Works, City Hall.

Sealed Tenders, on official forms only, endorsed "Tender for.....Works Department" to be lodged in my office before Twelve o'clock noon on 12th February.

The lowest or any Tender will not necessarily be accepted.

The whole or any part of a Tender may be accepted.

An official receipt must be obtained for every Tender delivered by hand. Tenders sent by post must be registered.

R. MEYER,
Town Clerk.
K 272

Re VIXOL, Limited.

By Order of B. D. HOLROYD, Esq., the Controller appointed by the Board of Trade, Messrs. FULLER, HORSEY, SONS & CASSELL are instructed to invite

Tenders for the Purchase of

LOTS of the undermentioned
PLANT & MACHINERY
viz., Cylindrical Still with Lead Condenser, Cast Iron Condenser Tank, Three Jacketted Boiling Pans, Experimental Filter Press, Rotary Pump, 5 in. Screw Cutting Lathe, by Pfeil, Treadle Lathe, Watchmaker's Bench Lathe, Three Fly Presses, Benches and Fittings and other Effects.

Tenders to be delivered by Twelve noon on Thursday, February 14th, at the offices of the Auctioneers, 133, High Holborn, W.C. 1.

Catalogues and Forms of Tender, when ready, may be had of FULLER, HORSEY & CO., 133, High Holborn, W.C. 1 K 240

Re the TANDEM SMELTING COMPANY, Ltd.

By Order of B. D. HOLROYD, Esq., F.C.A., the Controller appointed by the Board of Trade, Messrs. FULLER, HORSEY, SONS & CASSELL are instructed to invite

Tenders for the Purchase of

the undermentioned:—
VALUABLE LETTERS PATENT
granted to Herbert Frederick Hoveler for improvements in

LIQUID FUEL BURNERS.

No. of Patent.	Date Granted.	Period.	Country.
105112	Mar. 30, '16	14 yrs.	Great
6644/'10	Mar. 16, '10	14 yrs.	Britain and
21675/'07	Sept. 30, '07	14 yrs.	Ireland.

The Burners may, by permission of the Occupiers, be seen in operation at the Tandem Smelting Works, Merton Abbey, on Steam Boilers and Smelting Furnaces, and every opportunity will be afforded intending purchasers to satisfy themselves as to the merits claimed by the Patentee. There will be included in the purchase the

STOCK OF BURNERS,

Spare Parts and Accessories, now stored at the Merton Abbey Works.

Tenders, which must be in the form contained in the Particulars, should be delivered under seal marked "Tender for Burner Patents," at the Offices of the Controller, B. D. HOLROYD, Esq., F.C.A., 6, Great Winchester Street, by Twelve o'clock noon, on Monday, February 25th, 1918.

Particulars of the Patents, with Conditions of Sale and the opinion of Mr. A. J. WALKER, K.C., thereon, may be had when ready of Messrs. HOLROYD, WEST & NORTHCOTT, Chartered Accountants, 6, Great Winchester Street, E.C. 2; of Messrs. MAWBY, MAWBY & MORRIS, Solicitors, 6 & 7, Queen Street, Cheapside, E.C. 4, or of Messrs. FULLER, HORSEY & CO., 133, High Holborn, W.C. 1. K 241

PORT OF BRISTOL.

FERRO-CONCRETE BUILT SUPERSTRUCTURE FOR COLD STORES, AVONMOUTH DOCKS.

The Docks Committee invite

Tenders for the Construction

and Maintenance of a Ferro-Concrete built Superstructure for Cold Stores, Avonmouth Docks.

On and after Monday, the 18th February, 1918, copy of the form of Tender, General Conditions, Specification, and Schedule of Quantities, and a copy of the Contract Drawings, can be obtained from the undersigned on production of a receipt showing that a deposit of £5 has been paid to the Secretary of the Docks Committee, to whom all cheques must be made payable. The deposit of £5 will be returned to all bona fide tenderers hereafter.

Tenders must be enclosed in a sealed envelope, endorsed "Tender for Superstructure for Cold Stores," and addressed to the Secretary of the Docks Committee, Docks Office, 19, Queen Square, Bristol, and must be delivered to him accompanied by the prescribed documents and drawings before Ten a.m. on Monday, the 11th March, 1918.

The Docks Committee do not bind themselves to accept the lowest or any tender.

THOMAS A. PHAGE,
Engineer.

Docks Engineer's Office,
Avonmouth Docks,
Bristol.
5th February, 1918. K 308

LONDON COUNTY COUNCIL.

Tenders are Invited for the

SUPPLY of 4500 FORGED STEEL DRIVING WHEEL TYRES and 3000 FORGED STEEL TRAILING WHEEL TYRES for Electric Tramcars. The Form of Tender may be obtained from the General Manager, London County Council Tramways, 20, Belvedere Road, Lambeth, S.E. 1. No Tender received at the County Hall, Spring Gardens, S.W., after Four p.m. on Monday, the 18th February, 1918, will be considered. The Council does not bind itself to accept any Tender.

JAMES BIRD, K 285
Clerk of the London County Council.

APPOINTMENTS OPEN.

Accountant Wanted,

thoroughly competent to take complete charge of commercial and cost books in engineering works, West Riding of Yorkshire, protection card or ineligible. Will be required to furnish analyses, monthly trading accounts, &c. Good position to thoroughly reliable competent man.—Address, stating age, salary, experience, &c., in strict confidence, K 324, Offices of Engineering. No one already engaged on Government work need apply. K 324

Cost Accountant Wanted for

large Marine Engineering Works (Controlled establishment) in Glasgow.

Must have thorough experience of all branches (wages, materials and oncost) including final costing and first-class knowledge of the most modern methods; should be capable of controlling staff.

Applications should also state age, full particulars of experience and enclose copies of references to

ACCOUNTANT,
Wm. Porteous & Co.,
Advertising Agents,
Glasgow.

K 316

Analytical and Metallurgical

CHEMIST REQUIRED, to take charge of Laboratory and Heat Treatment Plant. Experience in handling of high-grade tool and automobile steels desirable. Birmingham district. No one already employed on Government work need apply. —Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and K 242.

METROPOLITAN
BOROUGH OF HAMMERSMITH.

ELECTRICITY DEPARTMENT.

The Council of the Metropolitan Borough of Hammersmith invite

Applications from Properly

qualified man for the post of:—

(a) METER SUPERINTENDENT.

Salary £160 per annum, rising by two annual increments of £7 10s. to £175 per annum, plus War Bonus of 20s. weekly.

(b) ENGINEER-IN-CHARGE.

Salary £175 per annum, rising by annual increments of £12 10s. to £200 per annum, plus War Bonus of 20s. weekly.

The appointment will be subject to one week's notice on either side, in each case.

Applications, stating experience and accompanied by copies of three recent testimonials, must be delivered to the Borough Electrical Engineer, Electricity Works, 85, Fulham Palace Road, Hammersmith, W. 6, not later than Thursday, February 21st.

Candidates canvassing members of the Borough Council will be disqualified.

Town Hall, LESLIE GORDON,
Hammersmith, W. 6, Town Clerk.
5th February, 1918. K 341

Wanted, in Government

Factory, METALLURGICAL CHEMIST, able to control pyrometers, including standardisation and up-keep, with thorough knowledge of photo-micrography of steel and non-ferrous alloys and general routine of metallurgy. No person already engaged on Government work need apply.—Apply your nearest EMPLOYMENT EXCHANGE, quoting No. A 4533. K 187

General Works Chemist; also

a CHEMIST with Micro-metallographic experience for work in connection with Aero and Motor construction. No one already on Government work will be engaged.—Reply, stating experience, age, salary expected, to LABOUR DEPARTMENT, Austin Motor Co., Ltd., Longbridge Works, Northfield, Birmingham. K 173

Required, by High-class Firm

of Motor Car and Aero Engine Manufacturers, a competent ENGINEERING LECTURER, B.Sc. in Engineering preferred. Would be required to lecture apprentices and lady students, conduct periodical examinations, and be responsible for keeping all records of apprentices' and students' progress, both practically and technically, in terms of a specifically laid down syllabus. No person already employed on Government work will be engaged.—Apply nearest EMPLOYMENT EXCHANGE, mentioning No. A 4487. K 128

Wanted, Works Manager, for

growing concern in North Midlands area, Manufacturers, Constructional Engineers, Gas Plant, Sheet Metal Work, &c., employing about 70 hands. Thoroughly practical man required, to take live interest in business. Six o'clock man essential. First-class salary paid to first-class man; possible view to Directorship. This is a genuine application to infuse new blood into a prosperous concern of which the senior principal is desirous of additional help. Send full details of past experience, salary required, the whole of which will be treated in the strictest of confidence.—Address, K 200, Offices of Engineering.

Wanted, Erecting Engineer,

with experience in the erection of large coke oven plants, for firm in the Sheffield District. Apply, giving full experience, salary required, &c. —Address, K 273, Offices of Engineering.

Wanted, by Leading Boiler

Insurance Company, additional BOILER INSPECTORS for the London District. Applicants must be practical Engineers with a technical training capable of making accurately dimensioned sketches of all classes of steam boilers, and of writing clear reports on condition. Commencing salary £150 per annum, plus War bonus. Applicants must be ineligible for Military service but not exceeding 45 years of age.—Address, K 328, Offices of Engineering.

Works Manager.—Required,

a thoroughly competent WORKS MANAGER, up to all modern shop practice, to take entire charge of a large factory concerned in the manufacture of electrical and scientific apparatus. Good salary to first-class man.—Address, K 275, Offices of Engineering.

Trained Mechanical Engineer,

with thorough knowledge of up-to-date methods, REQUIRED as Assistant Works Manager, to organise expansions of novel urgent Government work (Aviation), London District. Salary commensurated with ability and progress effected. No one already on Government work or resident more than 10 miles away will be employed.—Address, K 333, Offices of Engineering.

Rate Fixer Required, by an

Engineering firm manufacturing Aero Engines in the neighbourhood of Bristol. One used to time study and process on up-to-date methods of machining and fitting. Good salary to right man. Applications from those already on Government work cannot be entertained. — Apply nearest EMPLOYMENT EXCHANGE, mentioning this paper and No. K 320.

A Well-known Firm of

Machinists and Engineers in the Manchester District REQUIRE Immediately a Competent MAN, to take charge of installation and supervision of new department on important war work. It is desired to engage someone of such capacity and experience that he will, when this special work is finished, be able to take position as works manager in works employing 200 hands. Will applicant please give full particulars of experience, age, salary required, &c. No person already employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4577. K 305

Reinforced Concrete Designer

REQUIRED, for urgent War work.—Write, stating terms and experience, BOX 3740, care of Brown's, 39, Tothill Street, Westminster. K 286

Required, the Services of an

ENGINEER to design and superintend the construction of a small hydraulic press.—X Box, 977, care of Judds, 97, Gresham Street, E.C. 2. K 313

Required, for a London

Institution, an ENGINEER, to assist as Teacher. A practical man, College trained, with experience in teaching, preferred. State age, experience and salary required, and enclose copies of testimonials.—Address, K 282, Offices of Engineering.

Heating and Ventilating

ENGINEER REQUIRED. Capable of preparing schemes and taking charge of work. State age, experience and salary required. No one living more than ten miles away or on Government work need apply.—K 298, Offices of Engineering.

Draughtsman Wanted for

Government work for factory near Woolwich for Automatic Machine Design. No one at present on Government work or residing more than ten miles distant need apply. State age, experience and salary required.—Address, K 306, Offices of Engineering.

Heating and Ventilating.—

DRAUGHTSMAN REQUIRED, capable of preparing Schemes and Estimates. State age, experience and salary required. No one living more than ten miles away or on Government work need apply.—K 299, Offices of Engineering.

Electrical Draughtsmen Re-

QUIRED, used to ship work. Apply, giving experience, age and salary required. No one already employed on Government work engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and K 259.

Draughtsman Wanted by a

large Controlled Engineering Works, within a hundred miles of London; age about 30, with good mechanical engineering training; up-to-date experience, Portable and Traction Steam Engines and Boilers essential. No person already engaged on Government work will be engaged.—Address, stating fully age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4435 and this Journal. K 9

Draughtsman Wanted, with

first-class Mechanical Engineering experience. Some knowledge of Lifting Machinery an advantage. Apply to your nearest EMPLOYMENT EXCHANGE, stating age, experience and salary required, mentioning No. A 4425. No person already engaged on Government work need apply. K

Mechanical Draughtsmen

WANTED, for large Engineering Works in Lancashire, conversant with Turbo Station layouts, also design of surface and jet condensing plant. Apply, stating age, experience, and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4312. K 198

LITERATURE.

Evaporating, Condensing and Cooling Apparatus, Explanations, Formulæ and Tables for Use in Practice. By E. HAUSBRAND, translated from the second, revised, German edition by A. C. WRIGHT, M.A., B.Sc. Second English edition, revised. London: Scott, Greenwood and Son. [Price 12*s.* 6*d.* net.]

THE first edition of this work was published in 1899, and a translation was published in 1902. The appearance of this edition, fourteen years later, without any material addition or alteration, suggests that little has been done to advance our knowledge concerning heat transference in the interval. The attention paid in recent years to the phenomena of radiation, as well as to the economical employment of steam and of thermal power plant, is opposed to this view. Many experiments, though not immediately directed to this particular inquiry, might have been made applicable, and it is not a little disappointing that more recent results have not been incorporated. The explanation probably is that experiments made in the laboratory have been found to have little relation to commercial operations, while the results derived from large-scale investigations have been treasured as valuable trade secrets. Nevertheless, inquiries that are independent of the form of apparatus, as, for example, the pressures exerted by rarified and compressed gases and vapours on floating drops, can be best prosecuted under laboratory arrangement. There are other problems in physics outside commercial aims that have no doubt received attention and could have been profitably employed, but this work gives no intimation of progress. On the other hand, many of the conclusions deduced from practical experiments are strictly applicable only to the apparatus employed, owing to the number and character of the variables that enter. The author over and over again warns against the danger of reading into the results an accuracy greater than they possess. His experience, as well as his theoretical knowledge, convince him of the need of a liberal allowance to cover a number of unknown factors.

The complexity of the problem and the necessity for caution will appear if a few of these disturbing factors are considered. From elementary considerations it may be asserted that the action of the heating surface and the efficiency of the apparatus is proportional to the difference in temperature between the fluids on each side of the division or surface. That is to say, if steam be used, it is desirable that its temperature should be considerably higher than the boiling-point of the liquid to be evaporated. It is therefore advantageous to use steam at a pressure of several atmospheres, but the most economical pressure remains indeterminate. Similarly the difference of temperature can be increased by maintaining a partial vacuum over the boiling liquid, but the limiting pressure is equally uncertain. For though the transference of heat is assisted by an increase of temperature, the improvement is by no means proportional to the increase, and indeed beyond certain limits, under given conditions, the efficiency may diminish. This anomalous result is attributed to the increasingly rapid movement of the particles of liquid over the heated surface, and, in a lesser degree probably, to the unequal pressure and temperature of the steam within the steam space. The effect is said to be more noticeable in heating non-boiling liquids by means of saturated steam, than in evaporating.

Another source of uncertainty whose effect has to be eliminated from the gross result is the variable amount of air carried by the steam, for this air operates adversely to the ready transference of heat. Further, since the conductivity of water is low, the effect of the condensed water formed from the steam precipitated on the heating surface will be unfavourable and operate irregularly according to the deposition. The apparatus itself has also to be considered; the conductivity of the metal forming the heating surface, the amount of incrustation accumulated, the dimensions of the coil, if that form be adopted, all bring fresh perplexities. In double bottoms and wide-jacketed apparatus comparisons are made still more difficult by the varying distance that may separate the boiler from the evaporator, the number and form of the entrances for the steam, the bore of the pipe, and especially the wide space in which the steam can spread. Evidently a problem of no common difficulty faces the experimenter on the one hand and the distiller on the other. The author states of this collection of disturbing factors that their effect in diminishing the estimate of the transference of heat based on laboratory researches is so great, that frequently the agreement of the observed action with that deduced from thermodynamical theory cannot be recognised.

In face of the hypothetical character attaching to many of the explanations the author is under the impression that the practical engineer would be disinclined to undertake the study of the necessary literature, or to found laborious calculations on the uncertain data that might reward his search. His object has therefore been to construct tables which shall represent probable conditions under wide variations of the constants. His work must have been heavy, but apparently well spent. If one distrusts the data generally accepted, it is easy to substitute other, if thought to represent the conditions of the problem more nearly. Many of these tables are of double entry, which makes interpolation difficult, but it is useless to seek for any great accuracy.

It is not an easy task to indicate the ground covered by these tables, 76 in all. The effects of opposite and parallel currents are shown by the quantity of cooling water and the extent of cooling surface required to produce a definite result. The mean difference in temperature is seen to be greater with parallel than with opposite currents, whence it follows that an opposite current apparatus has to be constructed on a larger scale than the parallel. On the other hand, the working costs are lower with opposite currents, and, under the same conditions, higher temperatures in the heating and lower in the cooling apparatus can be attained than with the parallel form. A short table, but one of great practical importance, is that exhibiting the coefficient of transmission of heat for variations in thickness of the different metals usually employed in evaporating plant, as copper, zinc, iron and lead. Relatively the percentages may be trustworthy, but the degree of uncertainty in absolute measures is shown by the wide limits it is necessary to assign to the coefficient of transmission; two values are adopted, one being double the other. The general conclusion to be drawn is, that the lower the conductivity of the metal, the more does the coefficient of transmission decrease with the thickness of the metal. For copper, in which the thickness of the wall rarely exceeds 4 mm., the decrease is negligible, considering the general vagueness. With wrought iron, requiring thicker walls, the unfavourable influence is at once apparent, and with cast-iron 10 mm. thick the efficiency is reduced to one-half. Lead, used in thick-walled pipes, is at the bottom of the list. The order of deterioration could have been anticipated, but remembering Lord Kelvin's dictum, one likes to have a numerical value expressing the rate of decrease. If the author's tables cannot reach final accuracy, he has done good work by making the extent of our shortcomings known. Again, the extent to which heat transmission is affected by the length and diameter of the pipes in use is a very practical point, and it is distinctly disappointing to be told that owing to the want of experiments of sufficient accuracy, our information in this direction has made no advance in the last twenty years. Fully conscious of its limited application, the author supplies a formula in which the transmission is shown to vary inversely as the square root of the product of the length by the diameter of the pipe. The need of trustworthy experiment is urgent, the deficient information makes us receive with some hesitation the values given in many tables, especially when we are warned that it may be necessary to allow a safety margin of 20 per cent. or 30 per cent.

The description of the mechanism employed in evaporation includes the general theory of the multiple evaporator. In a rather elaborate discussion of the efficiency of the apparatus and of the consumption of steam, the complexity of the formulæ materially increases, without apparently a corresponding increase in the numerical accuracy of the deduced tables. No blame attaches to the author on this account. He calculates, with the accuracy at his command, the evaporative capacity of the single parts of the apparatus for a large number of different conditions, chosen arbitrarily, with particular attention to limiting values. Such tables have the merit of indicating approximately the results that would follow from any variations in the data of the problem that the engineer or designer may think it desirable to introduce, or, alternatively, they show the direction in which the data must be varied to produce a desired result.

Ebullition is a subject that receives much attention. The action of a current of steam on floating drops of water has both a physical and commercial interest. It is contended that steam bubbles, together with the small drops of liquid thrown out of the boiling pans, constitute a real source of loss in evaporating liquids, but in any case, since a current of gas or vapour acting on finely divided sprays of liquid is employed in some forms of condensers, the behaviour of the steam, varying both in density and velocity, becomes an important subject of inquiry. The practical conclusion at which the author arrives is that the steam and foam bubbles may be best retained by bringing them into such a position that they are converted into solid drops, which the current is powerless to remove. That is the mechanical principle adopted in some froth-separating apparatus now on the market—the steam leaving the machine at high pressure is made to pass into a space in which the pressure is lower. The excess of pressure that is produced in the interior of the bubbles causes them to burst. The whole merit of such foam separators consists in possessing such adaptability that the necessary differences of pressure can be secured as the working conditions alter.

Condensers, separated into the two recognised forms "wet" and "dry," naturally occupy a large section. In the former, usually arranged for parallel currents, the pumping machinery extracts the condensed vapours and injected water as well as the air and uncondensed vapours; in the latter, adopting the principle of opposite currents, only the air and uncondensed vapour are removed by the air pump, the injected water being carried off by other means. Perhaps the difference between the two forms can be more clearly indicated by pointing out that in the parallel current type the steam enters at the top, together with the water, in the form of a fine spray, and both move downwards with different velocities, that of the cool steam diminishing on its downward path, while the velocity of the water increases. The water and uncondensed gases collect in the lower part of the condenser and are exhausted by the air pump. In counter-current condensers the steam enters below and the finely-divided water spray above. The steam rises and the cool water falls. From the bottom of the condenser the injected water and condensed steam simply flow away spontaneously. The aim is, in construction, that on leaving the cooling water should have the temperature of the entering steam. This condition implies a very fine spray of water and a slowly rising current of steam, only compatible with a condenser of great height and large diameter. The desired conditions can, however, be brought about by making the water fall in stages or steps, a fresh surface being encountered at each step. The most judicious arrangement of the number and depth of these falls, the distribution of the water, and the transmission of heat to water presenting a large surface in comparison to its volume, raise some problems of physical interest. These are solved after making some permissible or inevitable approximations and the results exhibited as usual in the form of tables.

The last few chapters are devoted to the discussion of the work of the air pump and the efficiency of that form of apparatus. One result is to show that, for any determined vacuum and any temperature of the injected water, there is a definite most favourable temperature for the waste water at which the volume of air to be exhausted is least. This is a very practical deduction from general theory, and before leaving the book we would emphasise the fact that on many other points, to which it has been impossible to refer, the author

has succeeded in blending theory and practice very judiciously. This summary should prove as useful in promoting design as in assisting those who have to use evaporating machinery.

Turbines Applied to Marine Propulsion. By Stanley J. Reed, Assoc.M.Inst.C.E. Second edition, revised and enlarged. London: Constable and Co., Limited.

A tragic interest attaches to the second edition of this treatise on the marine turbine, the author having lost his life on duty when the Princess Irene blew up in the Thames. Mr. Reed had a long experience in marine turbine design and construction, first at Barrow and afterwards on the staff of Sir John Biles, where he had much to do with the introduction of geared turbines into cross-Channel steamers. He had just completed the revision of his treatise when the war broke out.

The basis of the book is a series of lectures delivered by Mr. Reed as a special course at the Naval Architecture Department. These dealt mainly with the turbine from the thermodynamic and hydraulic aspects, and proved so interesting and instructive that a desire was expressed for their publication in book form. This was done after careful revision, and has been supplemented by much other matter. Included in this are lavishly illustrated descriptions of the principal types of marine turbine so far brought forward.

Mr. Reed had made a special study of the relative advantages and disadvantages of different types of reduction gearing, and a special value attaches accordingly to his observations on mechanical, hydraulic and electrical systems. Similar praise may be awarded to the concluding chapter of the book, which consists of a series of general notes on the construction and operation of marine turbines. The considerations which should govern the design of the principal details are clearly set forth. Particular attention is directed to the importance of ample provision for drainage, defects in the arrangements fitted having been responsible for a number of serious strips. The work is illustrated by 119 engravings, many of which are large folding plates.

Laboratory Manual of Bituminous Materials for the Use of Students in Highway Engineering. By Prevost Hubbard, Chemical Engineer. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd. [Price 7*s.* net.]

The water-bound roads of macadam stand condemned, not so much by the inferiority of the completed surface, as by the temporary discomfort they entail on the road user during construction, and the wear and tear of horse and vehicle, by whose aid the irregular pieces of granite are welded into a closely compacted surface. The introduction of the heavy roller took some of the work off the ordinary traffic, and by its means the surface was completed more expeditiously, but aggravated other evils of which not the least was mud in wet, and dust in dry weather. The speed of the motor car and the increased weight of mechanical transport have forced upon the highway engineer the need of further improvements, and he is required to produce a road that shall be impervious to water, without any great tendency to disintegration, that shall not be slippery or greasy, give foothold to horses, and be suitable to all kinds of traffic. The authorities and ratepayers ask at the same time that the cost of construction and maintenance should not be increased. To meet these somewhat incompatible demands the engineer has endeavoured to substitute tarry components for mud binding, and the success has been so great that there is no doubt but that whatever be the nature of the weight-bearing foundation, the surface of the road of the future will be one truly bound together by some pitchy or bituminous material, forming a crust possessing real cohesion, into which water will not penetrate and the surface will not crumble under evaporation. As a consequence of this revolution in road-making, within the last few years bituminous materials of all kinds have acquired an enhanced commercial importance, and it has become necessary to classify them according to their fitness for special purposes. The differences of chemical composition and the mechanical treatment to which the raw material is submitted give to these bitumens qualities that can be detected only in the laboratory, and possibly only incompletely with such aid, but an approximate knowledge of their properties is of great assistance to the engineer. He is required to work with a material of which he has had only little experience, and though protection from fraud may be desirable, it is more important that he should be able to select or specify the material best adapted for the purpose in view. The testing and examination of bituminous material has inaugurated almost a new industry, and in America, where such products are more plentiful than with us, it has been found necessary to provide courses of laboratory instruction in this subject in the schools of highway engineering. The subject does not appear to have been sufficiently systematised to have produced a manual especially devoted to testing. This want the author seeks to supply. Apparently he addresses both those students who are preparing for such a course, and engineers who may be actually in practice and have some simple laboratory equipment at their command, but have not been trained in practical testing and the interpretation of results.

The book is divided into three sections. In the first some useful definitions are given, but the sketchy nature of the information leaves a rather unsatisfactory impression, only to be removed as the author gets to work on the practical methods of testing, the description of which occupies the second and by far the largest section. The tests for different properties are classified according to the agent employed. Thus we have density, or specific gravity, tests; consistency; heat; and solubility in carbon disulphide or other chemicals. In addition some miscellaneous processes are detailed, among which may be included the extraction of bituminous aggregates. The student is always told carefully what is the object of the test, and usually some warning is given as to the degree of trustworthiness to be placed upon the result. For instance, though the use of the Engler viscosimeter is not discouraged, it is distinctly pointed out that the instrument is not well adapted for determining the specific viscosity of many bituminous materials at 25 deg. C., and therefore the general advice is given that it is desirable to limit the use of this viscosimeter to materials intended for cold surface application, and to utilise some other form of test for indicating the consistency at normal temperatures of those materials which have to be heated before application. As an alternative we have the "float test," and its advantages and limitations are clearly and properly insisted upon. This form is recommended for determining the consistency of tars irrespective of their free carbon content, but caution is needed when testing the semi-solid blown-oil products that are not good conductors of heat. On the reliability of the melting-point test we meet with another kind of caution. Bituminous products have no definite melting-point; any method, therefore, of determining the melting-point is purely arbitrary, and gives purely arbitrary results. There is no escape from the fact that different methods do give different results for the same material. In reporting results, or preparing specifications, it is necessary to indicate the method adopted. Though both the so-called "cube" and "ring and ball" methods are explained and illustrated, it is asserted that no absolute definite relation has as yet been found to exist between these two methods.

When two methods of testing recognised in the profession as reliable, give discordant results, it is easy to suggest that neither is probably correct, and to throw discredit on the whole plan and purpose of testing. Such a conclusion would be unworthy, but the sneer emphasises the necessity of devising methods whose results should be above suspicion. We quote these remarks as illustrating the practical character of the book, and because they carry a very useful warning to two classes into whose hands a certificate of test may fall. The members of one class distrust the laboratory and all its works, care nothing for control tests, and do not wish to identify the material or ascertain its method of manufacture. They prefer to rely upon their unassisted judgment and previous experience. The other class are inclined to look upon the cabbalistic symbols of the expert chemist as containing something infallible, to be treated with veneration as the outcome of inviolable science. Both are wrong, and the author's careful balancing of the causes that influence the numerical expression of an inherent property, and discussion of the circumstances that have to be considered in interpreting it, should do something to make the value of a test better understood. Each class may find something in any test to warrant his confidence or confirm his mistrust. In the ductility test the sceptic may point to the admission that the examination as conducted in no way represents the behaviour of the comparatively thin films of material that exist in a bituminous pavement. On the other hand, the true believer will hold to the theory that ductility is a measure of adhesiveness and make his arrangements accordingly. Mr. Hubbard has done his best to insist on the importance of maintaining a just proportion.

The third section of the book is devoted to the description of the characteristics of those bituminous materials that find application in road-making. This section should prove of assistance to the highway engineer who wants to select a product especially adapted for a required result. For example, among fluid petroleum products he will find indicated the qualities suitable for a dust preventive, a carpeting medium, &c., or from the analysis of many samples he may select that best fitted for the end in view. In semi-solid and solid petroleums and asphalt products a trustworthy guide is still more necessary, for it must not be overlooked that the method of distillation operates on the final result not less than does the type of oil distilled. Because of such ambiguous interpretation, the identification, control and selection of a product becomes increasingly perplexing. Another class of products in which the guidance of the expert is of advantage is that which arises from fluxing the refined native asphalts with residual petroleums. Fluxes which have proved suitable for one asphalt will not always produce satisfactory asphalt cements for another asphalt, and the study of various combinations is economical of both labour and material. Remarks on these important practical topics, and particularly on the subject of bituminous aggregates, might have been extended with profit, because wide experience has not been gained in their use. Aggregates, it is true, are not bituminous materials. Local necessity usually decides their character, and except in the matter of size and grading cannot be subject to test, but in road-making they play an important part and one that the student cannot afford to neglect. Doubtless, however, such problems can be better treated in a separate treatise, which we hope the author will be tempted to produce.

Aeronautics: Second Annual Report of the National Advisory Committee for Aeronautics, for the Fiscal Year ending June 30, 1916. Washington Government Printing Office.

The second annual report of the National (United States) Advisory Committee for Aeronautics has now been published, and it covers the work of the committee for the twelve months ended June 30, 1916. Naturally, research on aeronautics has much less intensive in the United States during the past three years than it has on this side of the Atlantic, where, however, very little has been published for reasons sufficiently obvious. Even such minor matters as the methods used for calculating the stresses on the structure of the machines is for the present treated as an official secret. In an introduction to the report the American committee refer to the very limited funds placed at their disposal by Congress, which has made it impracticable to arrange for more than one of the special reports on the state of the art which they had in contemplation and which, if that now published may be taken as a sample, will prove of the utmost value. This deals with the carburettor. and includes an exhaustive *résumé* of all carburettor patents applied for during the past few years. These have been appropriatedly classified, the objects the various inventors had in view being clearly explained, and the means proposed to attain the desired ends fully set forth. This review of the patents is prefaced by an introductory note on the nature of the problem, contributed by Mr. Charles E. Luck, who has further added a note on the theoretical aspect of the question, in which he discusses the

various formulas which have been proposed for the flow of fluids through tubes and orifices, in which the author points out the unreliability, in the conditions under which carburettors work, of formulas which make the flow simply proportional to $\sqrt{2gh}$. He suggests that to put the design of carburettors on a rational basis the line of advance must be in the direction pointed out by Professor C. H. Lees in his paper on the "Laws of Skin Friction," which was published in our issue of June 2, 1916. Mr. Lucke also describes a number of experiments made with ten representative American carburettors, in which their flow characteristics and accuracy of regulation were determined under running conditions. An important point brought out was that the plan of plotting the weight of gasoline against the weight of air with different throttle openings gives an inadequate idea as to the fluctation of the mixture proportions, since the gasoline scale is necessarily so much smaller than that of the air. An illustrated description is given of each carburettor tested, but without mention of the makers' names. This report on carburettors occupies some 500 pages out of a total 630. The remaining matter includes a report by L. Mardies on "Experimental Researches on the Resistance of the Air," which deals exclusively with work done in France. This *résumé* will undoubtedly be of great value to those unable to consult the original memoirs, of which a complete bibliography is given in an appendix to the report.

Laws of Physical Science. By EDWIN F. NORTHRUP, Ph.D., Princeton University, New Jersey. Philadelphia and London: J. B. Lippincott Company. [Price 8s. 6d. net, bound.]

DR. NORTHRUP'S "Laws of Physical Science" are something of a novelty. Since some of the data of physical science are readily accessible in tables of constants, and the mathematics have been formulated in many books, he wished to prepare a reference work containing a full list of the general propositions or laws of science. He makes this statement in his preface, and he admits that many general propositions and mere statements of facts, which he has included in this volume, could not be strictly discriminated as laws. When doubt existed, he has followed a policy of inclusion by preference to one of exclusion. In pursuance of this plan he classifies 480 brief enumerations of laws and facts in six sections on Mechanics; Hydrostatics, Hydrodynamics and Capillarity; Sound; Heat and Physical Chemistry; Electricity and Magnetism; Light. He quotes the respective law not necessarily in its original version, but rather in the clearer form it subsequently assumed, and he does not as a rule refer to the original research, but to its exposition in some recognised text-book of science, giving volume and page. It is all very concise, and we find on an average about three items on each of the 210 pages of the volume; this number includes the alphabetical index. The arrangement has its advantages; it was hardly necessary, however, to include the titles of American journals like the *General Electric Review* and the *Journal of the Franklin Institute* in the bibliography list of books. With the exception of one French text-book, all these books are in English or English translations. The many references to "Ganot's Physics" are explained by the popularity which that text-book enjoys in America, and we certainly do not object to the frequent quotations from Jeans either; he was for some time professor in Princetown.

We might call the book a dictionary of physical facts. No dictionary can be complete, and we will point out a few omissions. The book knows only molecules, not atoms. Atoms may be strictly chemical, of course, but atomic heat and atomic volume have become very physical of late, and physical chemistry is one of the divisions mentioned. There is no mention of "equations of state," and Van der Waals' formula is alone given. We have critical temperature defined, but not critical pressure, and there are no statements concerning states of aggregation and liquefaction. Dr. Northrup has not attempted to define the principle of relativity in a few words, which may be wise; but the absence of references to telephony and telegraphy is surprising in a book which naturally makes a good deal of electricity, partly Dr. Northrup's own subject. The exclusion of radioactivity does not call for comment; a definition of electrolytic dissociation ought certainly to have been given, however, and a reference to Maxwell on the effect of pressure on electrolysis is hardly satisfactory in view of the recent researches on that subject.

BOOKS RECEIVED.

The Distances, Absolute Magnitudes and Spectra of 734 Stars arranged for Use with ordinary Star Maps. By THOMAS EDWARD HEATH, F.R.A.S. Tenby: Published for the benefit of the Tenby War Emergency Depôt, South Cliff-street, Tenby. [Price 2s. 6d.]

Modern Underpinning, Development, Methods and Typical Examples. By LAZARUS WHITE, C.E., and EDMUND ASTLEY PRENTICE, Jr., E.M. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 7s. net.]

Water Supply (Considered Principally from a Sanitary Standpoint). By WILLIAM P. MASON. Fourth edition, rewritten. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 17s. 6d. net.]

The Elements of Refrigeration; A Text-Book for Students and Warehousemen. By ARTHUR M. GREENE, Jr. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 18s. 6d. net.]

A Fraudulent Standard: An Exposure of the Fraudulent Character of our Monetary Standard with Suggestions for the Establishment of an Invariable Unit of Value. By ARTHUR KITSON. London: P. S. King and Son, Limited. [Price 7s. 6d. net.]

The Year Book of the Universities of the Empire, 1916 and 1917. Published for the Universities Bureau of the British Empire. London: Herbert Jenkins, Limited. [Price 7s. 6d. net.]

Wood and Other Organic Structural Materials. By CHARLES HENRY SNOW, C.E., Sc.D. London: Hill Publishing Company, Limited. [Price 21s.]

The Work and Training of the Royal Flying Corps. London: Published by the authority of the Royal Flying Corps at the offices of *The London Illustrated News.* [Price 2s. 6d. net.]

Precision Grinding Machines. By THOMAS R. SHAW, A.M.I.Mech.E. London: Scott, Greenwood and Son. [Price 10s. 6d. net.]

Machine Design, Construction and Drawing. By HENRY J. SPOONER, M.I.Mech.E. Fourth edition, revised. London: Longmans, Green and Co. [Price 12s. 6d. net.]

Industrial Engineering; Present Position and Post-War Outlook. By F. W. LANCHESTER. London: Constable and Co., Limited. [Price 1s. net.]

Practical Mathematics. By EDWARD L. BATES and FREDERICK CHARLESWORTH. Second edition, revised. London: B. T. Batsford, Limited. [Price 5s. net.]

The Daily Mail Year Book for 1918. Edited by DAVID WILLIAMSON. London: Associated Newspapers, Limited. [Price 9d. net.]

The Motor Manual. Twenty-first edition. London: Temple Press, Limited. [Price 2s. net.]

Ministero dei Lavori Pubblici-Reale Commissione per gli Studi sul Regime Idraulico del Po. Ufficio Idrografico del Po. Seconda Pubblicazione (dal Dicembre, 1913, al Giugno, 1917). Parma; Premiato Tipografie Ruinite Donati, 1917.

First Report of the Indian Railway Bridge Committee. August, 1917. Delhi; Superintendent, Government Printing.

Practical Electricity. By TERRELL CROFT. London: Hill Publishing Company, Limited. [Price 10s. 6d.]

Industrial Unrest: The Reports of the Commissioners (July, 1917) Collated and Epitomised. By Sir WILLIAM CHANCE, Bart., M.A., Chairman of Committee, British Constitution Association. London: P. S. King and Son, Limited. [Price 1s. net.]

Telegraph Practice. A Study of Comparative Method. By JOHN LEE, M.A. London: Longmans, Green and Co. [Price 2s. 6d. net.]

Motors in a Nutshell. By Captain S. BRAMLEY-MOORE, M.C., Assoc.M.Inst.Mech.E. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 1s. 6d. net.]

La Compagnie Anglo-Belge de l'Afrique Oriental Allemande. Par CHARLES STIENON. Paris: Berger-Leorault. [Price 6 francs.]

BIG IRON DEPOSITS IN QUEENSLAND.—Some of the reports prepared by Dr. Jack for the Queensland Parliament indicate that that State possesses enormous deposits of iron. One of the chief deposits is at Iron Island, described by Dr. Jack as rich hematite ore, and he added that unlimited quantities of the present limestone were available in the vicinity of Mount Lucy, about 10 miles from Cairms, on the Chillagoo line. Dr. Jack reported the location of an enormous outcrop of exceedingly pure magnetite, in which crystals containing as much as a cubic foot can be obtained. He described the iron mountain at Kangaroo Hills, near Townsville, as an enormous bed of magnetic iron ore, of vast proportions. A special report was prepared of Mount Leviathan, in the Cloncurry district, as a mass, say, 200 ft., and ¼ mile in diameter at its base, of the purest possible iron ore, the greater part of which is specular iron ore. In the same report he described Mount Pisa as a hill of iron ore, very like Mount Leviathan, but not rising to such an enormous mass. Dr. Jack reported upon a large lode of pure magnetic ore on the Wild River, 60 miles from Maroochy, also upon deposits at Gladstone, at Pittsworth (on the Downs) in which the assay was 62 per cent. of iron; at Biggenden, Degilbo and Mount Perry, and stated that other large deposits were to be found on the Don River in the Mount Morgan district.

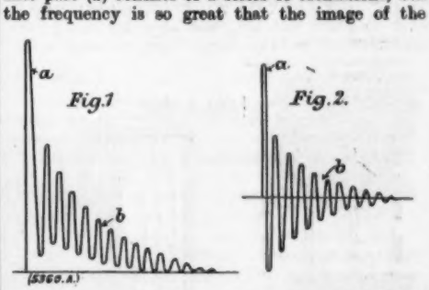
TESTING ELECTRIC IGNITION APPARATUS.

Note on the Measurement of Current in Electric Ignition Spark Circuits.

By J. D. MORGAN, A.M.I.C.E., A.M.I.E.E.

IN connection with the testing of electric ignition apparatus, namely, magnetos and induction coils, it is required to measure the current in the high tension spark circuit. Owing to the complex character of the current, the problem of measurement is a difficult one. At present the problem appears to be incapable of complete solution, and the task of producing a practical instrument resolves itself into devising means which will give useful indications when subjected to the actions of different currents having the same general characteristics.

The currents in the spark circuit of a magneto or induction coil are intermittent and oscillatory. In most cases the oscillations are superimposed on a unidirectional discharge. Also the oscillations are divisible into two successive parts, in the first of which the frequency is enormously higher than in the second. Plotting current against time, the general characteristics of a single discharge are related as shown in Fig. 1. In some special cases the discharge is as shown in Fig. 2. Possibly, the first part (*a*) consists of a series of oscillations, but the frequency is so great that the image of the



spark in a rotating mirror is seen as a single bright line. The image of the second part (*b*) is seen as a row of parallel lines, which are much less bright than the first. It is to the current corresponding to the first bright line in the spark image that the difficulty of current measurement is due. This current is associated with the self-capacity of the spark generator. When the interrupter in the primary circuit is opened there is a rapid change of flux in the system. For a short interval at the commencement of this change a small quantity of current is stored due to the self-capacity of the generator. When the voltage reaches such a value that it breaks down the spark gap, the stored current discharges and produces the first part of the spark. It follows that this part of the spark has a practically constant value.

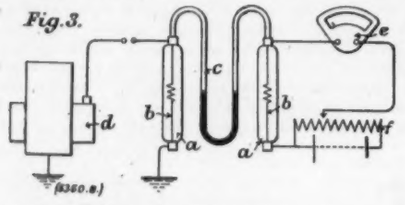
In all ignition apparatus the current in the spark circuit depends on the speed of operation of the spark generator, and the size of the spark gap. In magnetos provided with means for varying the position at which the contact breaker is opened in the revolution of the armature, current variations also accompany adjustment of the contact breaker. The character of the variations found in a normal magneto are as follows:—Keeping the gap constant and fixing the contact breaker, the current increases with the speed. Keeping the speed constant without varying the contact breaker, the current increases with diminution of the spark gap. Keeping the gap and speed constant the current diminishes at low speeds when the contact breaker is moved from the "advanced" to the "retarded" position, and at high speed increases continuously or passes through a maximum value with the same adjustment of the contact breaker.

Obviously, any current-measuring instrument to be useful, must be capable of indicating the changes above mentioned, and to anyone unfamiliar with the problem it may appear remarkable that there should be any pitfall to avoid in constructing a suitable instrument. Some form of thermal ammeter or galvanometer is likely to give the best results, and several forms have been tried with ignition apparatus. In two, the heated element carrying the current to be measured, consisted of

extremely fine wire of comparatively low resistance. These instruments were of exquisite construction, but both showed a surprising behaviour. With each a diminution of current was indicated with a diminution of spark gap instead of an expected increase. One indicated a constant current, instead of a current which increased to a maximum, and then decreased when at a certain speed of the magneto, the contact breaker cam was moved from the advanced to the retarded position. Both gave at all speeds current values which were known to be much too high. One of these instruments was made to behave in a proper manner by Mr. E. A. Watson by the inclusion in the instrument circuit of an inductance and a capacity which shunted the extra-high frequency component of the current past the instrument, and allowed only the component of lower frequency to pass through it.

Proceeding on different lines, the writer concurrently developed for his own work another type of instrument, the scheme of which is shown diagrammatically at Fig. 3, and the general appearance at

Fig. 3.



(5360. B.)

Fig. 4.

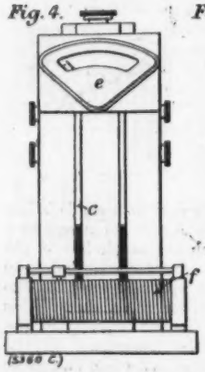
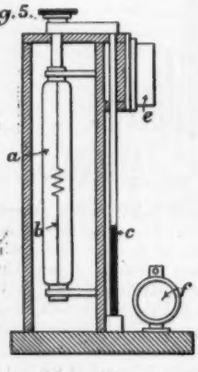


Fig. 5.



(5360 C.)

Figs. 4 and 5. A pair of similar glass chambers *a* containing a metal or carbon filament *b* are connected to a capillary fluid indicator tube *c*. One of the filaments is connected to the spark circuit of the magneto *d* as shown, whilst the other is connected to a battery circuit through a milliammeter *e* and variable resistance *f*. The heating of one of the chambers by the magneto current is balanced by the heating of the other by the battery current. With the particular filaments used, it is found near enough for practical purposes to take the milliammeter readings as the equivalent of the magneto current when the balance is obtained. Comparison with the instrument corrected by Mr. Watson shows that the indications of the two instruments agree very closely.

An essential condition of success in the instrument shown in Fig. 3 is that the filaments shall be of relatively high resistance. In the first model 16 c.p. carbon filament lamps were used, these having a resistance of 1,500 ohms each. Later cylindrical lamps recognisable in the drawings, and provided with comparatively thick metal filaments of 500 ohms resistance, were used, and found quite satisfactory. These instruments are sufficiently sensitive, and show the current variations which are expected from the theory of the ignition apparatus under test.

In designing thermal ammeters for complex currents having widely different oscillatory components, it is necessary to pay careful attention to the heated element. If the element is made of low resistance, the instrument readings will be determined mainly, if not solely, by the high-frequency component of the current, whilst if wire of high resistance is used the readings will be determined mainly, if not solely, by the low-frequency component. Taking a typical experiment, one of the instruments first mentioned in this article was connected to a magneto, and its indication was found to be not only excessively high, but also constant for all positions of the contact breaker cam when the speed was kept constant. The only component of the current which could remain constant under this condition was the extra-high frequency component and the current value attained in it is undoubtedly much higher than in the other. Using the writer's instrument the current value was much lower, and repeating the test, the expected variations were indicated.

It follows from the foregoing, that different types of thermal instruments and varieties of the same type, can give very different accounts of the same piece of ignition apparatus. Further, it follows that in setting up a standard instrument it is necessary to settle beforehand which of the two current components shall be taken as the main or sole basis of comparison. A variety of considerations which are irrelevent to this article, and which are based on the properties of ignition apparatus, as well as on certain ignition phenomena, lead the writer to the conclusion that it is the current of lower frequency which is the more useful for comparative measurements.

THE THIN COAL SEAMS OF EASTERN CANADA.

In continuation of the policy of investigating the mineral resources of the Dominion, the Canadian Department of Mines has issued a monograph* describing the thin-coal seams scattered throughout the Maritime Provinces, particularly in New Brunswick, discussing the possibility of developing these seams with the view of increasing the immediate output and of prolonging the life of the coal industry. Whatever be the result as measured by increased activity, such inquiries are of the utmost value, bringing together and utilising much scattered information that was not methodically preserved at the time of its collection, because its importance was not perceived. These records now acquire additional weight by reason of their systematic comparison, and being conducted under Government auspices, the trustworthiness and impartial character of the conclusions are guaranteed. Private investigations are too liable to be confined to inquiring whether the working of a seam will have satisfactory results for the shareholders; the outlook of the Government is wider and asks: will the working of the seam benefit the community at large? Many an area has been abandoned because it failed to yield a satisfactory profit to the shareholders. In such case the issue is confused, the desirability of extracting a latent source of wealth is not distinguished from the return on capital invested. Mr. Brown says very pithily "There is a distinction with a difference between a mine failing to pay and the coal seam failing to day."

In other countries where coal is plentiful and thick seams abound, mining policy has been directed to the extraction of the easier-worked seams, the duty to posterity being regarded as sufficiently discharged if the thin seams are left intact, and in such condition as to be available for the future. Mr. Brown, impressed by the spectre of approaching exhaustion, by the difficulties of undersea working and by the severe competition from the United States, urges the immediate operation of the thin coals, not only as the best means of utiliising the seams themselves during the time when their extraction would yield the greatest return to the provinces, but also with the view of preserving the more valuable coals, whose life as a commercial asset is strictly limited. The total tonnage of coal is computed at about 7,000,000,000 tons, and the coal in thin seams, that is of less than 3 ft., about half this quantity. With increasing output and the operation of adverse conditions, 100 years may be regarded as the limit of possible working. Hence the necessity for a thoroughly co-ordinated system, embracing the whole coal-producing area, is pressing. In the best interests of the community there is no room for financial speculation and little for local competition, other than the keen determination to secure the most economical results. The factors on which such a system will be founded must have regard to the records of geological exploration and drill work, the possible mechanical improvements in mining machinery, the physical consequences of working thick and thin seams in adjoining strata, skilful organisation, including control of labour, together with other elements which are more or less common to all mining exploitation.

A typical section plotted from data derived from Government drills is shown in Fig. 1, and illustrates the general conditions prevalent in Cape Breton Island. From inspection it is clear that the number of thin seams is not only greater than the number of thick, but that the distribution is by no means regular or convenient. The main result drawn from the investigation of boreholes is that 46 coal seams, less than 3 ft. 6 in. in thickness, have been bored through, and 25 beds over that thickness. All these are not independent, separate, seams, drillings having been made more than once in the same bed, but this is not likely to invalidate the concluded relative percentage of thick and thin coals, and therefore it is probable that on the entire coalfield, some 65 per cent. consists of thin seams whose treatment demands especial precautions and whose complete exhaustion may not prove possible. In New Brunswick, the home of thin seams, the geological information is not so clear or so extensive as could be wished. Fig. 2 exhibits the results of eight borings in the Grand Lake District, revealing the existence of seams ranging from 20 in. to 30 in. in thickness. Apparently these borings are little more than superficial. Possibly the nature of the underlying strata demonstrated the uselessness of prosecuting further inquiry, but from the data submitted, it may be concluded that the latent possibilities of coal-mining in New Brunswick demand further attention. The proved quantity of something less than 200,000,000 tons, covering an area of 136 sq. miles, is but a small contribution to the Dominions' available supply.

What constitutes a thin seam and at what point profitable operation ceases, are problems that interest not only the mining community, but influence the onward progress of industry and commerce. The exhaustion of the more attractive seams in mines that have been long worked has compelled proprietors to consider the alternatives of abandonment, or the possibility of operating thinner seams neglected in the days of prosperity. Comparatively little attention has been paid to the form of mining that is best adapted to meet the difficulties presented by this gradually-altering condition, and this report is a valuable contribution to the general problem, inasmuch as the discussion is founded on wide experience. The result is not the less welcome since on the whole a favourable view of the possibilities of thin-seam working is foreshadowed. The author is, however, careful to point out that success in mining one thin coal is no guarantee that similar success will follow in another. Some operators cannot make a 6-ft. seam pay, while others have worked on 18 in. with profit. A thick seam may be defined, therefore, as one that pays to work, and a thin seam one that does not, though this latter result may arise from uneconomical management, the use of unsuitable machinery, or over-capitalisation, as well as from the character of the coal mined, or the prices obtained for the fuel. With reference to physical reasons alone, in hand operations coal cannot be mined at a less thickness than about 18 in., and then the means for removing the coal must be conveniently arranged in order to prevent loss from excessive breakage. The Royal Commission on Coal Supplies adopted 12 in. as the lowest possible working thickness, but this figure has been brought within practical range solely by improvements in mining machinery.

Various causes with which engineers are familiar may forbid or hinder the use of machinery. Roof troubles and inherently weak strata that will not resist the greater stress that usually accompanies longwall mining—the form best adapted to thin seams—are among the chief of these obstacles under normal conditions, but inefficient labour and the

* "The Mining of Thin-Coal Seams as Applied to the Eastern Coalfields of Canada." By I. F. Kellock Brown. Ottawa: Government Printing Bureau, 1917.

want of intelligent organisation often increase the physical disabilities. In some cases, where machinery might be usefully employed, lack of capital stands in the way, but the greatest difficulty to be overcome in East Canada arises apparently from the conservative habits of the miners who cling to obsolete methods. These men have lived in isolated districts, without facilities for becoming acquainted with modern mining methods, and vigorously oppose the adoption of novel processes. To grasp the present position of the coal industry, particularly in New Brunswick, all these factors have to be estimated, and it will be admitted that unfortunately great mining difficulties have asserted themselves precisely where the conditions for overcoming them are most feeble. Mr. Brown fights strenuously against the lethargy and want of initiative too often apparent, and though he is happily able to quote some instances which display unusual vigour and resource, he leaves the impression that stagnation is generally rife. That enterprise and capacity are not wanting in individual cases is evidenced by the working of a seam, with satisfactory profit, only 13½ in. to 16 in. thick, in spite of bad roof and other drawbacks. In another case, the difficulties of which will be readily appreciated from the diagram, Fig. 3, successful results have been obtained. Here are shown two beds of coal, 13 in. and 14 in., respectively, separated by 12 in. of hard clay. Above the top coal, 18 in. of unpayable material have to be taken down before the roof proper is reached. The seam consists of 30 in. of foreign material and 27 in. of coal. Under such circumstances it will be admitted that the thin-coal miner is severely handicapped, and stands in need of every device that ingenuity can supply if the mine is to be profitably operated.

The adoption of machinery, however, should not be partial, and this is one point on which the author insists, here indicating, we imagine, a policy that has the approval of the Department of Mines. The object is to get better results, per ton, per man, than can be achieved by hand labour. To introduce some one contrivance, as a coal-cutting machine, is to express dissatisfaction with ancient methods and to recognise the necessity for alteration, but does not solve the problem of cheapest possible extraction. If competition with mines more easily worked is to be successful, a thorough revolution is needed, one that aims at the application of power to the entire process of extraction, from undercutting to the conveyance of the coal in mine cars. Dislocation of organisation, involving a decrease in efficiency, may very well follow any attempt to combine the two systems, as the author well says, "the half that is done by machines is always waiting on the half that is done by hand, and is retarded by it, involving an inevitable increase of cost."

The particular feature in thin-coal mining which forces itself on the attention is the limited space in which operations have to be conducted. To construct a cutter so restricted in height that it can crawl between the roof and the pavement is to encounter a serious difficulty. Owing to the fluctuations in the thickness of the coal, the breaking and taking down the roof are frequently necessary after all possible reductions in size have been made. The author suggests that running skids or flats are preferable to wheels, since not only is the height reduced, but in addition the use of a truck along the face may be dispensed with. This restriction of inches in the height of a machine brings home very forcibly the limitations imposed by a thin seam. Its importance outweighs the competitive advantages claimed by the chain, the bar, and the disc types. In one or other of these forms—the chain is the more frequently employed—mechanical cutters have come into general use. The adoption of a mechanical conveyor on a complete scale is not so general, at least that is the impression gathered from the description of those in use elsewhere, and the remarks on the choice of such an accessory. Some kind of mechanical device has no doubt been found indispensable, but the more important forms described here as the "shaking screen" and the "chain belt" system are little in vogue. The former is apparently more suitable for very thin or inclined seams, requiring very little power, and has proved itself very efficient for air drives. It cannot, however, be reversed, and will therefore not deliver timber to the men. These are factors that affect coal-mining generally, and have no particular restriction to thin coals. A mechanical loader for thin-coal long-wall mining has yet to be designed, but is urgently necessary to complete the cycle of operations that will ensure the highest efficiency and economy in thin-coal extraction. As in the case of the coal cutter, so here, the dimensions, being limited, impose severe restrictions; the height the material is to be lifted and the distance it has to be dumped are both matters of inches. The whole mechanism has to be fitted into a space not exceeding 16 in. in height. The machine will have to be self-propelling, making use probably of chain tread or a "caterpillar" device, but it will have to travel at the same rate as the cutter in order to "eat up" its work and keep the face properly cleaned up within a reasonable time. There appears to be a large demand for a convenient machine, and if power can be applied cheaply it should go a long way to solving the problem of economical extraction. In the case of hand-filling, 6 tons per man per hour may be considered a fair average rate. The loader, however, should be designed to clean up 20 tons to 40 tons in the same time. The author, looking hopefully forward to the advent of this type of machine, concludes that "it ought to be quite possible to obtain 500 tons per day from a 100-yard face, and this should be produced by the machine, with a squad of 50 men, bringing the tonnage up to about 10 tons per man. At present the tonnage recovered per man employed underground is 2.6 tons; to quadruple this quantity at one stroke by displacing the slower and older methods is a delightful, if elusive, prospect. The author, however, considers the result as of quite possible achievement.

There is little necessity to discuss the relative merits of "longwall" and "pillar" mining. Longwall, either advancing or retreating, has generally proved more suitable in thin veins, but the determining factor in the choice is commonly the local circumstances, such as the nature of the roof, the amount of experienced labour available, or the necessity of providing a quick return on the capital invested. In the absence of exceptional circumstances, it is safe to say that "longwall" will be the natural path along which thin-coal operations will advance. That system is the one that secures the greatest tonnage within the smallest area, and provides the maximum of continuous work with the minimum of lost time. Panel working may sometimes be combined advantageously with "longwall," but here again usually the extra cost of development work, which in the thin seam may involve the dislodgement of a great quantity of waste rock, will influence the decision. It is of more importance to insist on the loss that may follow from too great eagerness to work the thicker and more remunerative coals. If the thin coals are neglected or improvidently treated, they may be irretrievably injured and become a total loss, though cases are known where it has been found profitable after the lapse of a number of years to reopen the beds, or to work the pillars that earlier miners have abandoned. Where two coals of different thickness are close together the thinner one is frequently left unworked and the community is the poorer by the waste. Since operating on either underlying, or overlying, thick coal may involve the sacrifice of the thinner, wherever possible, the contiguous seams should be worked together simultaneously, one in advance of the other, using the same roads. Mr. Brown suggests a very drastic method of proceeding where reckless destruction has followed non-economical extraction. He recommends that wherever a company refuses to modify its system so as to get the fullest output from a specified area, "the right of mining that seam should be rescinded, and consideration given to a plan for re-leasing to another operator under conditions which are protective to both."

Without taking too gloomy a view of the industry, the author perceives that it is not impossible but that in the near future Nova Scotia coal may be shut out from the St. Lawrence trade, and he looks around for some method of readjustment and reorganisation of the system, that will utilise to the greatest advantage the coals that are suitable for export to the outside markets, and at the same time furnish an adequate source of supply to the home market. He examines the Belgian mining laws and finds in them three cardinal features that might be introduced or enforced in Canada with good results. These give greater power to the Government in granting and withdrawing leases, in maintaining a protective oversight over all the operations, and particularly in insisting on a compulsory obligation placed on the operator,

Fig. 1. GEOLOGICAL SURVEY SECTIONS. BOULARDERIE, CAPE BRETON, N.S.

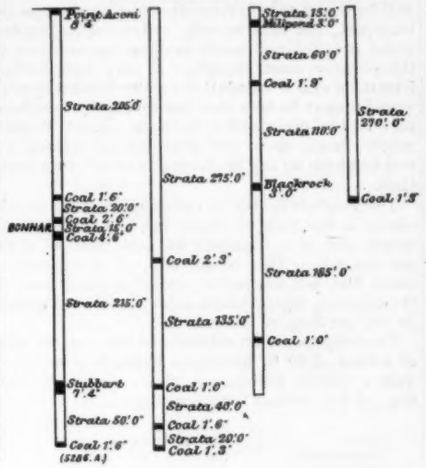
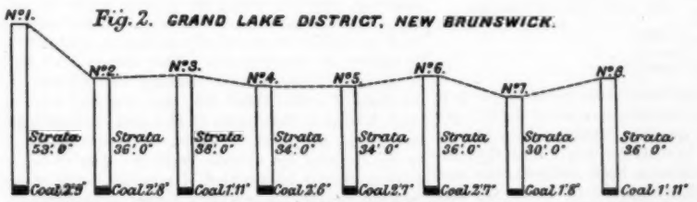


Fig. 2. GRAND LAKE DISTRICT, NEW BRUNSWICK.



No 1. Barnes Mine. No 3. Tweedie Mine. No 5. O'Leary Mine. No 7. Kelly Mine.
. 2. Kings . . 4. Cokely . . 6. Welton . . 8. Gibbons .
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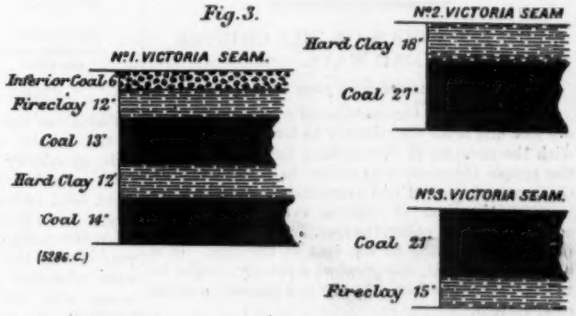
Fig. 3.



compelling him to comply with any co-operative measures that facilitate the working and despatch of products.

The author is a great advocate for co-operation. He considers that legitimatised co-operation would restrain destructive competition on the one hand and diminish the evils of monopoly on the other. There is, too, an additional reason for some form of co-operation, since with the small margin between mining and selling cost, no room exists for the capital and administrative charges inevitably connected with monopolistic operations. Finally, one other oppressive regulation calls for readjustment. The amount of royalty claimed is based, apparently, solely on the quantity of coal mined without any consideration of the difficulties encountered in mining. On a thin seam the ordinary royalty presses too heavily in proportion to the mining cost and operates as a deterrent to the working of the less remunerative beds. The subject of royalties is very thorny, one that it is very dangerous for an outsider to touch, but seeing the large extent to which the prosperous life of the Maritime Provinces depends upon the utilisation of its entire mineral resources, the ventilation of all causes that interfere with its due development is most desirable. Accurate knowledge of the prevailing conditions is essential to progress, and Mr. Brown's contribution to the subject marks the urgency of the problem and also indicates the anxiety of responsible, authorities to assist in handling the question systematically and intelligently.

THE ECONOMICS OF THE CHINESE RAILWAYS.

(Continued from page 86.)

Turning now to the question of economy the most obvious one is for the country to build the railways with the revenue of the existing lines or to induce the people themselves to invest in railways under Government control and guarantee. Foreign loans increase the cost of Chinese railways owing to commission and other charges, by 1,000*l.* to 800*l.* per mile, according to the cost of the line. It is believed that this, the greatest economy, might be to a large extent effected by the reorganisation of the road system.

These roads might serve as feeders to the existing railways, and would be infinitely cheaper both in first cost and operation than branch lines. The financial position of the Government railways shows that the majority of the lines are not worked to their full capacity. Thus, in 1915, of the 15 Government railways, only five were run at a profit, the net profit on all the railways amounting to about 800,000*l.*, practically all of which is derived from the Peking–Mukden (No. 5), Peking–Kalgan (No. 8), and Peking–Hankow (No. 13) Railways. Even on these lines receipts have apparently reached a maximum. Not one of the railways, even the paying lines, has reached the maximum capacity for single-line traffic. It is then obvious that an enormous source of revenue lies in the development of the existing railways. Thus, if the present mileage of Government railways would produce a net revenue of 600*l.* per mile, the annual revenue from this source would amount to 2,208,000*l.* sufficient to build 300 miles of new line per year. It should be stated that the net revenue per mile on the Peking–Mukden Railway amounts to 1,270*l.* at present. This line does not traverse the richest part of the country by any means, so that a net revenue of 600*l.* per mile can not be called an extravagant expectation.

Undoubtedly this development would be carried out most cheaply by road development, and in doing this China would only be following the example of European nations in the development of their overseas possessions. In every case road construction has gone hand in hand with the construction of railways, roads being built to tap those districts not sufficiently prosperous to be able to afford a railway.

These roads could be built to connect points on the railways with large towns 100 or more miles distant. In order to save expense they could be so located as to avoid crossing the bigger rivers, the existing railway bridges serving as communication across these. Bridges could be of reinforced concrete, old rail reinforcement being used, and all maintenance would thus be avoided. The Chinese are excellent at this work, which is less costly than steelwork. Piers and abutments cost about 3*l.* per 100 cub. ft. and the reinforced slab about 5*l.* per 100 cub. ft.

Needless to say that the roads would have to be well built, not only to stand the existing abominable transport, but also to take motor tractor traffic, which it is believed would develop the resources of the country most cheaply. A very well-drained formation and a foundation on the Telford system would appear to be a *sine qua non*, as the southern part of the plain suffers from an almost English winter, frost, snow and rain quickly alternating and breaking up any ill-drained road in a very short time.

The great difficulty in road construction in this region is the lack of stone, but the Government would give this transport at cost price of 0.2*d.* per ton-mile. This would add, at a maximum, about 10*d.* per ton to the cost of stone in cars in the quarries, where rubble costs 1*s.* 8*d.* and ballast 3*s.* 4*d.* per fang of 100 cub. ft.

The following is an estimate of the cost per mile of a road of 20 ft. formation width in 5 ft. bank, with a rubble foundation 12 in. deep and with 6 in. of 2-in. ballast for a dressing :—

	£	
Land	173	At 12*l.* per acre.
Earthwork ...	120	
Bridges	200	Openings 50 ft. per mile.
Road metal ...	551	100 mile rail haulage.
Contingencies, 10 per cent. ...	104	
Total ...	1,148	

China can thus build first-class roads in this part of the country at a maximum cost of 1,150*l.* per mile, proximity to quarries would reduce this to 900*l.* per mile, and in districts where both Government land and stone were both available the cost might be still further reduced to 720*l.* On this basis 800 miles of good roads could be built every year if only the present income from the railways were allocated to this purpose. Convict labour would still further reduce the cost if properly handled.

It has lately been suggested that China should lessen the cost of her railways by adopting narrow-gauge, costing 800*l.* to 1,000*l.* per mile. A price per mile like this of necessity entails the adoption of at least 2-ft. gauge and 30-lb. rails. An estimate of the cost of such a line and its traffic handling capacity should be of some interest.

It will be assumed that curvature will impose no limits on the rolling-stock, that is eight-coupled engines will be feasible, and that limiting grades of 1 in 150 will be obtainable. This implies that one of the chief money-saving qualities of narrow-gauge is at once eliminated in easy country like that in the Great Plain. In other words similar routes would be followed in such country, whatever the gauge. A maximum speed of 15 miles per hour will be assumed, with stations 5 miles apart. The following is the estimated cost per mile :—

	£	Remarks.
Land	110	4 ft. deep borrow pits.
Earthwork ...	77	5-ft. bank, 10 ft. formation.
Bridges ...	200	Axle loads 4 tons, as roads.
Permanent way	460	Rails and sleepers at 8*l.* per ton. 1,800 steel sleepers ; no ballast.
Rolling-stock ...	500	10-ton wagons, 8 coupled locomotives, weight 16 tons. Lines not exceeding 100 miles in length.
Stations ...	100	
Contingencies, 10 per cent. .	144	

Total cost 1,591, say, 1,600*l.* per mile.

Now the maximum capacity of this line, with stations and speeds as above, is certainly not more than 12 trains in the 24 hours, of which 2 at least will be passenger trains, leaving 10 trains of a gross total weight of 2,375 tons per day. If 40 per cent. of this is taken as paying load, then the daily capacity of this line does not exceed 950 tons, assuming no empty wagon mileage.

In view of the light rail, the absence of ballast and the cost of transhipment, it is extremely doubtful whether this traffic could be handled as cheaply as on the trunk lines of standard gauge, where it costs about 0.2*d.* per ton-mile. Also the use of mud ballast would be in the nature of an experiment, but this has been successfully tried with steel sleepers in tropical Africa, with a much bigger rainfall, but with a heavier rail and a lighter traffic than is proposed above.

When it is considered that the daily output of one small colliery employing 500 men is about 600 tons, the futility of narrow-gauge, of 950 tons daily, for coping with a district of enormous population and great mineral wealth is easily recognised. There is very little doubt that breaks of gauge should be kept out of the plain at all costs. The experience of the world is against such policy. India and Australia more especially have seriously considered converting all lines to one gauge. Indian conditions are somewhat those of China—labour is as cheap and many parts of the country are minerally rich. It has been found that narrow (metre) gauge working costs 25 per cent. more than broad (5 ft. 6-in. gauge), and that in spite of unlimited and cheap labour the delay caused by transhipment causes great congestion at busy times. This is in spite of the handicap of the 5-ft. 6-in. gauge loading limits.

Roads and motor tractors would appear then to be much the cheapest and most non-committal investment for a country like China, whose resources even now are very little known, and whose present financial position owing to a long series of disturbances is deplorable. The capacity of a road for traffic-handling is practically unlimited and merely a matter of maintenance. This should cost very little in a cheap labour country like China. In England it costs about 32*l.* per mile per annum, with labour at one-tenth of the cost it should not exceed 5*l.* per mile in China. This charge could easily be met by vehicle licences. The turnpike system should be avoided if possible, as it would be a loophole for trade stifling abuse. A Government Road Board assisted by foreigners would of course be a necessity.

Turning to the cost of motor traction in this country, the following is an estimate of the cost per ton-mile of a motor tractor carrying 8 tons and burning coal :—

	s.	*d.*
Wages, 1 driver	1	8
,, 1 helper...	0	6
Coal, ¼ ton	2	10
Oil and waste	1	0
Depreciation and maintenance ...	7	0*
Total daily cost	13	0

or 156 pence.

* This is at the rate of 20 per cent. per annum on 650*l.*, the cost of the tractor.

The average daily run would be about 60 miles, giving 480 ton-miles, at a cost of 156*d.*, or 0.32*d.* per ton-mile, against an improbable cost of 0.25*d.* per ton-mile on a 2-ft. narrow-gauge railway.

Should the Government adopt this road policy they will at any rate have given the people a chance of development they never had before. Easy access to the existing railway zones would be of enormous educational value, and would probably stimulate trades now stagnant or dying, while it would render easily possible the absolute suppression of the brigandage so rife everywhere at present.

The Government would of necessity encourage the idea of motor traction. There is no difficulty about the supply of drivers and mechanics. The Chinese make excellent drivers, are fair fitters and, best of all, have no trade unions, strikes or eight-hour days. The Chinese mechanic is a sober, quiet, and quite contented person on his magnificent wage of 10*d.* to 1*s.* 3*d.* per day. Roads at a maximum cost of 1,200*l.* per mile, of unlimited traffic-handling capacity, are undoubtedly a sounder investment than 2-ft. gauge lines costing 1,600*l.* per mile and with very limited capacity.

It should be stated here that the above cost of running motor tractors is deduced from Colonel Crompton's paper read to the Institute of Civil Engineers in 1908. Since then, of course, enormous developments in this type of traction have taken

10,000-KW. STEAM TURBINE AND CONDENSER FOR THE PEDRO MENDOZA POWER STATION, BUENOS AIRES.

CONSTRUCTED BY MESSRS. BROWN, BOVERI AND CO., ENGINEERS, BADEN, SWITZERLAND.

(*For Description, see Page* 141.)

Fig. 11.

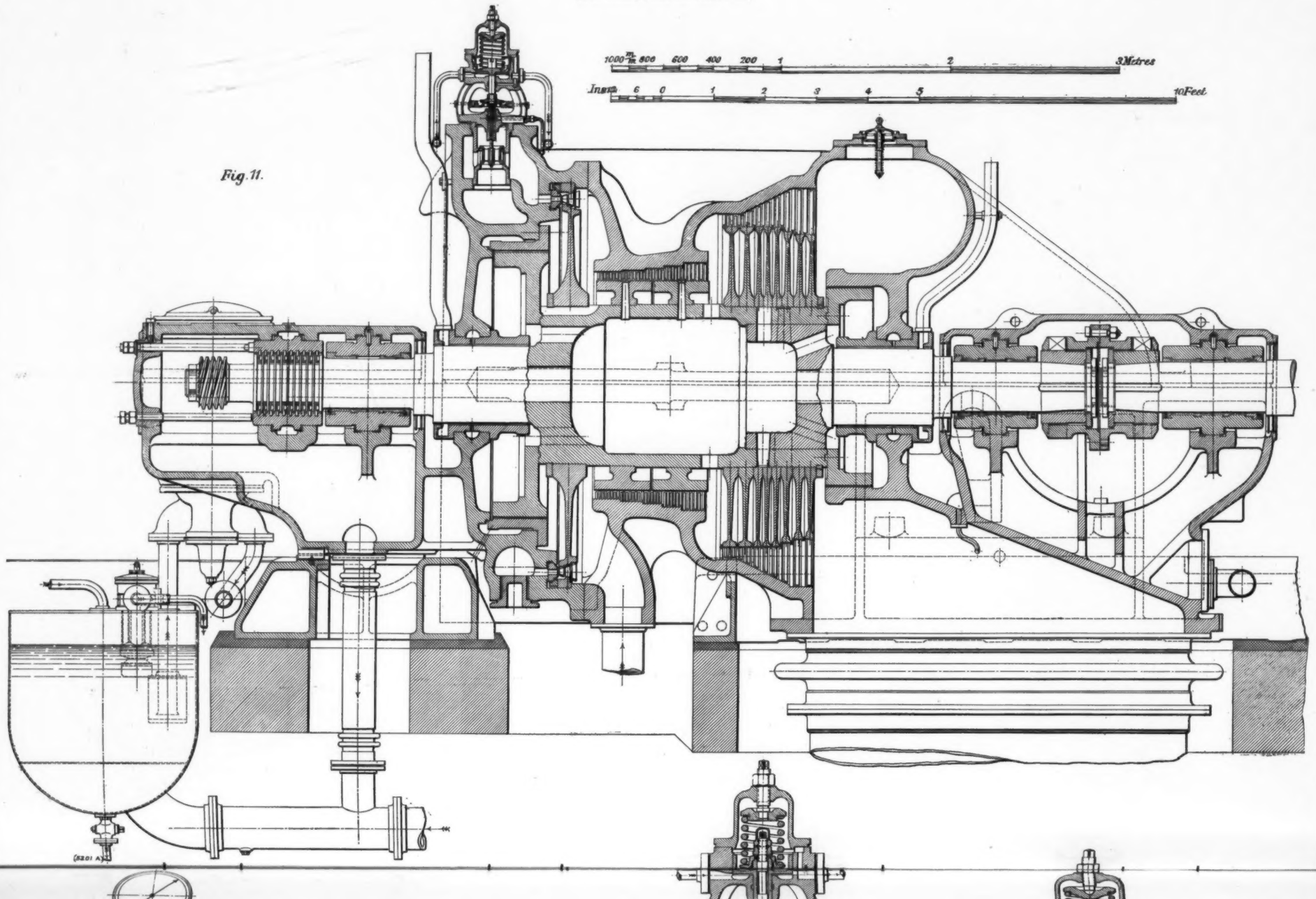


Fig. 12.

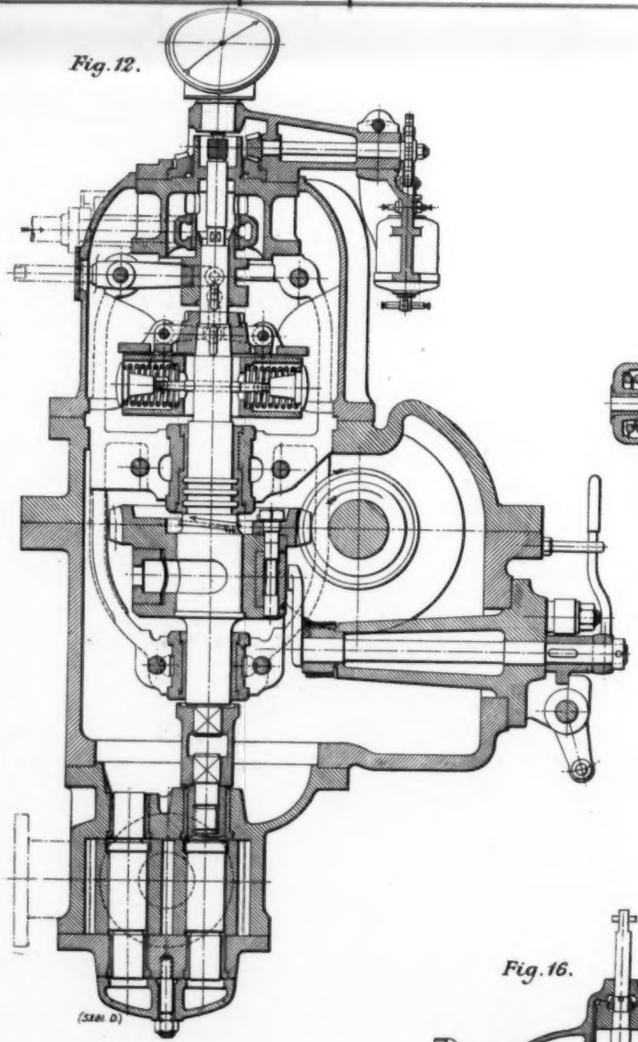


Fig. 13.

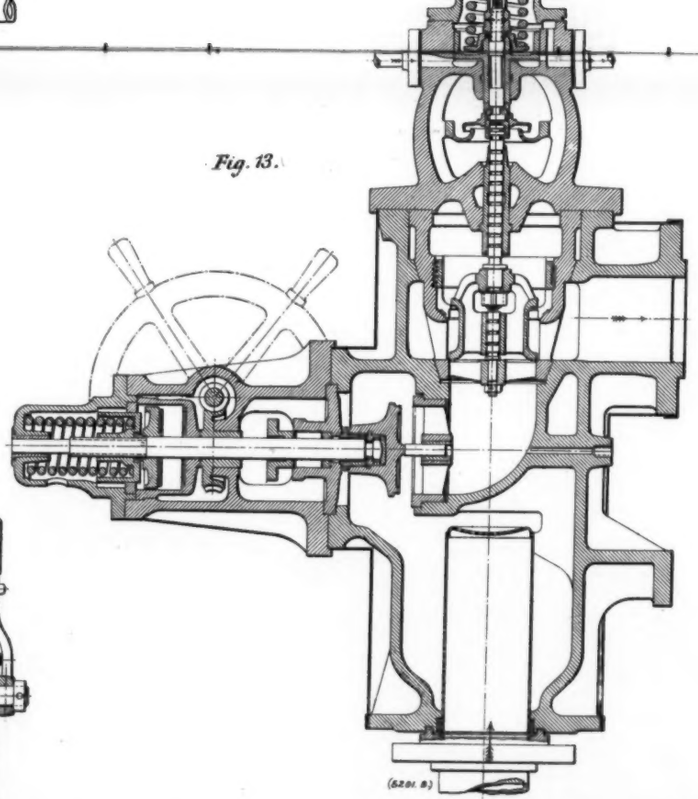


Fig. 14.

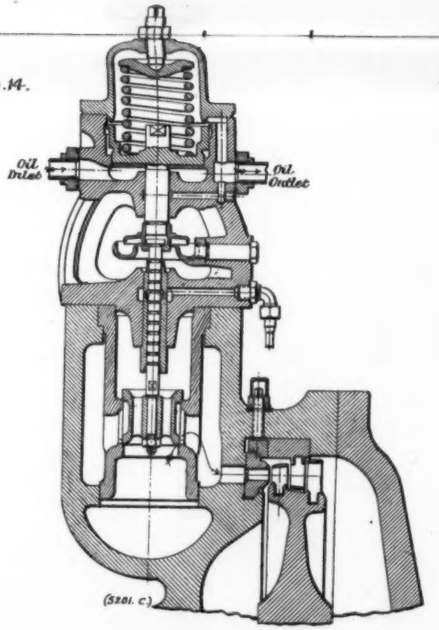


Fig. 15.

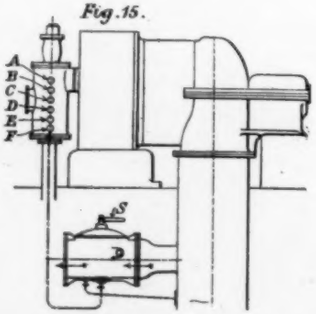


Fig. 16.

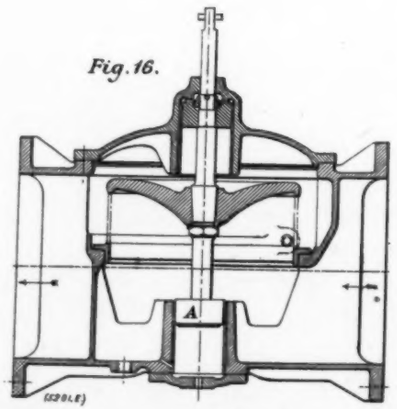


Fig. 17.

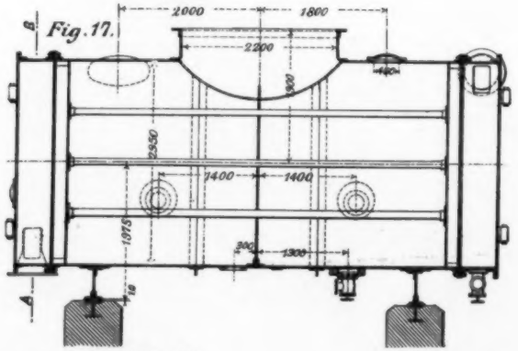


Fig. 18.

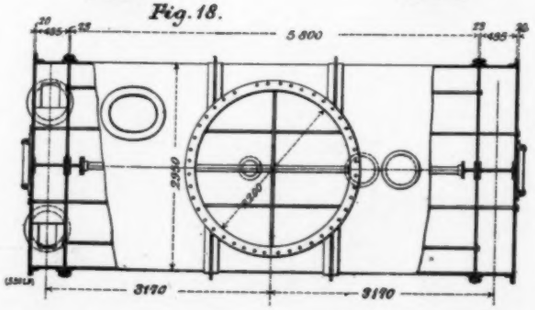


Fig. 19.

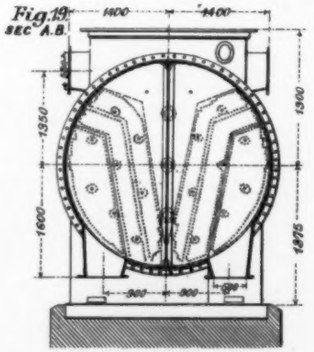


Fig. 20.

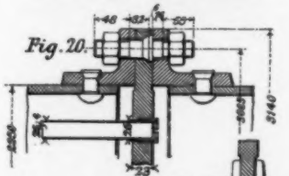


Fig. 21.

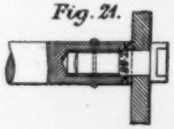


Fig. 22.

place. More recent but pre-war figures give the cost of running steam tractors at 0.1*d.* per ton-mile in England, and the cost of petrol tractors at 0.3*d.* per ton-mile. Cheaper labour and coal would probably reduce this in China, but this indicates that the first estimate cannot be considered too sanguine. In view of the fact that experience in the war has added so much to previous knowledge, motor traction afterwards should be still cheaper. Traction engines are, of course, about 50 per cent. cheaper than steam tractors, but 30 miles a day is their daily trip. They are also less costly in road maintenance. The advantage of motor traction and roads against light railways in mountainous country is still more marked. In this type of country, in order to avoid expense it would be necessary to adopt limits of grade and curvature of, say, 1 in 25, and 98 ft. radius, in addition to the 20-lb. rail.

Locomotives suitable for this weight of rail and curvature would not exceed 12 tons in weight and would haul a gross load of 44 tons. If 40 per cent. of this is taken as paying load, then the earning capacity of the line per train would not exceed 17 tons. It is unlikely that speeds would exceed 10 miles an hour, the maximum number of trains per day on this basis would be about six, giving a daily capacity of 102 tons. Further experience in China shows that the cost of working grades of this order is about twice that of lines in the plains with 1 in 150 grades. This would mean that this traffic would cost at least 0.4*d.* per ton-mile. It is also doubtful whether this type of line could be built at a cost of 1,600*l.* per mile, in spite of cheap stone and less bridging. Rock excavation would make the earthwork charge four times that in the previous estimate at least.

In the case of a road with good location, a limit of curvature of 50 ft. and grades of 1 in 30 should ensure cheap building. Stone and land would cost very little, and bridging would be reduced, enabling mountain roads to be built at a cost of 500*l.* to 600*l.* per mile. Grades of 1 in 30 would not in any way tax motor tractors which are built to negotiate hills as steep as 1 in 8. In this case there is no question that a road has not only an infinitely greater capacity than the cheapest possible railway, but is also much cheaper initially.

Roads should undoubtedly be built as pioneers of railways in the hill country south of the Yangtse. In this way the undoubtedly great mineral wealth of the province of Yunnan might be most cheaply developed; at present this province is dependent on mule and coolie transport over the most appalling roads for those districts off the metre-gauge line (No. 30), traffic on which is regularly interrupted in the wet season for weeks at a time.

As an indication of the value of roads in a country well supplied with railways, it may be mentioned that there were in England in 1914 50,000 commercial motor vehicles. Of these, 25,000 were petrol driven, of weight not exceeding 2 tons unladen, 20,000 petrol driven and 5,000 steam driven of a greater weight than this. That the railways in England also recognise that roads are an adjunct to railways is proved by the fact that the Great Western Railway use motor vehicles as feeders to their branch lines, in South Wales in particular.

It is of great importance that the benefits, so-called, of narrow-gauge should be properly appreciated. This is best shown by estimates for two feeder lines not exceeding 100 miles in length, and of 2-ft. and standard gauge following similar routes.

	2-ft. Gauge, 20-lb. Rail.		4 ft. 8½-in. Gauge, 40-lb. Rail.
	£		£
Land	110	(16 ft. formation)	142
Earthwork ...	77	5-ft. bank.	103
Bridges	200		500
Permanent way...	460		1,000
Rolling-stock ...	500		800
Stations	100		100
Contingencies, 10 per cent. ...	144		264
Total cost per mile	1,591 (say 1,600*l.*)		2,909 (say 3,000*l.*)

This effects a saving of 46.6 per cent. on the standard-gauge line. In the above estimate the 2-ft. gauge is, as before; that is, the line is unballasted with steel sleepers. One thousand eight hundred timber sleepers and 700 cub. yards of ballast for the same gauge would cost practically the same money. For the standard-gauge line 1,800 sleepers and only 1,300 cub. yards of ballast (giving 4 in. under sleeper) per mile have been allowed.

With respect to the vital question of the capacity of the two lines, by halving the rail weight the capacity of the 2-ft. gauge line is halved and by reducing the gauge speeds have been cut down from 30 miles to 15 miles an hour, further reducing the capacity of the narrow-gauge line to one-quarter that of the standard line. Now on the very fair assumption, considering cost of transhipment, that costs per train-mile on the two lines will be identical, charges per ton on the narrow-gauge line to meet even working expenses should be twice those on the standard-gauge line, assuming that the working expenses will be 50 per cent. of the gross receipts. It is therefore extremely doubtful whether the 2-ft. gauge would pay interest on capital if the 20-lb. rail was adopted as standard, unless trade-stifling rates were imposed. If the 40-lb. rail was adopted for 2-ft. gauge lines the capacity of the two gauges would be about 2 to 1 on account of speed restriction, and the saving per mile for the 2-ft. gauge would be as following:—

	£	
Earthwork	26	
Land	32	
Bridges	97	
Permanent way ...	220	
Total saving ...	375	(or a saving of 12.5 per cent. only.)

The standard-gauge line has twice the capacity of the narrow-gauge line. Traffic in rich country like the Great Plain is bound to come and the railway will eventually pay. On the justifiable basis of similar costs per train-mile, cost of transport should be in the ratio of 2 to 1 for the two lines. Interest, therefore, on twice the capital of the 2-ft. gauge line could be paid and the same net profit result, whereas only 12.5 per cent. extra capital is asked for. It should also be pointed out that for heavier lines, averaging, say, 20-ft. bank throughout, against 5-ft. bank in the previous estimate, the above saving would be reduced as follows:—

	£	
Land	19	
Earthwork	13	
Bridges	40	
Permanent way ...	220	
Total saving ...	292	(or 9.75 per cent. only).

From the above figure it is sufficiently apparent that 2 ft gauge has no case in a populous and potentially rich country like China and should be avoided at all costs.

Turning now to the cost of metre or 3-ft. 6-in. gauge as compared with standard-gauge lines using the 40-lb. rail, the savings that would result are as follows:—

	£	s.	
Land	14	10	13 ft. formation.
Earthwork	13	10	5-ft. bank.
Bridges	49	0	
Permanent way ...	110	0	
Total saving ...	187	0	(or only 6.25 per cent. of cost of standard-gauge line.)

In the Great Plain metre or 3-ft. 6-in. gauge lines would have practically the same capacity as standard gauge as curvature would be so slight as to have no checking effect on speeds. Working expenses would be virtually the same with the exception of the extra cost of transhipment. The cost in a country like India, of this item may be taken as a guide to probable cost in this country as labour is as plentiful and as cheap. This is as follows:—

Bulky goods	3½*d.* per ton
Grains	1½*d.* ,,
Average	1*d.* to 1½*d.*

In view, therefore, of the certainly of congestion at transhipment points when both lines are busy the paltry maximum saving of perhaps 7 per cent. on capital for metre gauge-lines would appear to be negligible. When the enormous potential wealth, the high order of intelligence of the population, their great numbers and small wages are considered there is very little room for doubt that at no very distant date every railway in this area will be able to work at its full capacity. Breaks of gauge should, therefore, on no account be tolerated here when the small savings which result are considered. The future must also be considered from a strategic point of view. In connection with this gauge question it is significant that the Japanese, at the close of the Russo-Japanese War, at once converted what is now the South Manchuria Railway (No. 4 in map) from 3-ft. 6-in. gauge to 4 ft. 8½ in. gauge, and shortly afterwards the 2-ft. 6-in. gauge line from Antung to Mukden. The Japanese are also seriously considering altering all the lines in Japan from 3-ft. 6-in. to 4-ft. 8½-in. gauge. China has already to cope with the gauge question but not to any serious extent. All the lines not of standard-gauge are metre, and the only one in the Plain is the Cheng Tai Railway (No. 14), but as this may be important in the future trunk system, and as the country traversed is minerally rich the break of gauge is regrettable. This line is at present only 151 miles in length but was exceeding costly, the country being rather difficult. The line cost 11,500*l.* per mile, whereas the standard-gauge line from Peking to Kalgan (No. 8) which is in very heavy country cost 8,200*l.* per mile exclusive of interest and financial charges.

Of other non-standard gauge lines the biggest is the Franch Yunnan Railway (No. 30) of which 289 miles is in Chinese territory out of a total of 534 miles. This is an isolated system, and if ever connected up with the Burmese Railways there would be no break of gauge. Another small metre-gauge line is the Tsi-Tsi-Har (No. 2) Light Railway, 17 miles in length, which was built at a cost of 1,735*l.* per mile in country similar to that in the Plain. It has 30-lb. rails and is run at a loss. China is thus not so far committed, at any rate, in the richest part of the country, to more than one gauge and should, therefore, profit by the experience of the world which is undoubtedly against break of gauge in a populous and potentially wealthy country.

(To be continued.)

ELECTRIC POWER SUPPLY AT BUENOS AIRES.

(Continued from page 61.)

WE referred in our issue of the 18th ult. to the solicitude shown in designing the power station that it should add to, rather than detract from the architectural amenities of the city. The success attending this effort will be appreciated on reference to Figs. 8 and 9, page 142, and which represent the principal façades of the building.

Fig. 10 is reproduced from a photograph of the turbine-room showing the three 5,000-kw. turbines originally installed. The plant here is being augmented by the addition of two 10,000-kw. units for which provision had been made in the original planning of the station as indicated in Fig. 5, Plate VII *ante*. Details of one of these larger machines are now illustrated on Plate XIII, Figs. 11 to 16. As shown in the longitudinal section, the turbine is of the disc and drum type. It was designed to develop 12,500 k.v.a. at the generator terminals in normal running, when supplied with steam at a stop-valve pressure of 190 lb. per square inch (gauge) and a superheat of 240 deg. F. The speed is 1,500 r.p.m. In view of the high steam temperature, expansion pieces are fitted to all the steam connection pipes. One of these is represented in Fig. 25, page 143. The most noticeable feature of the design is the adoption of a disc instead of a drum construction for the exhaust end of the turbine, although this operates on the reaction principle. This plan has been followed on account of the high peripheral speed, which is of the order of 600 ft. per second. The blading of the intermediate section is mounted on two drums which are independent of the main body of the rotor, for which it was thus possible to use lighter forgings than would otherwise have been necessary.

Details of the governor and oil pumps are illustrated by Fig. 12. The main governor has horizontal

ELECTRIC POWER SUPPLY AT BUENOS AIRES; PEDRO MENDOZA STATION.

Fig. 8.

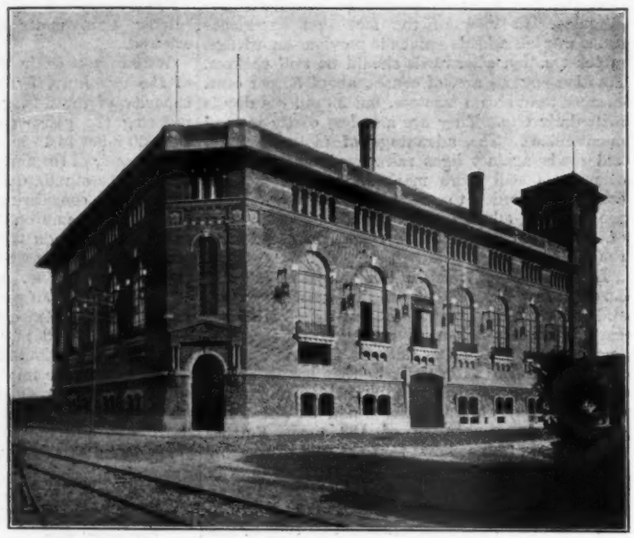


Fig. 9.

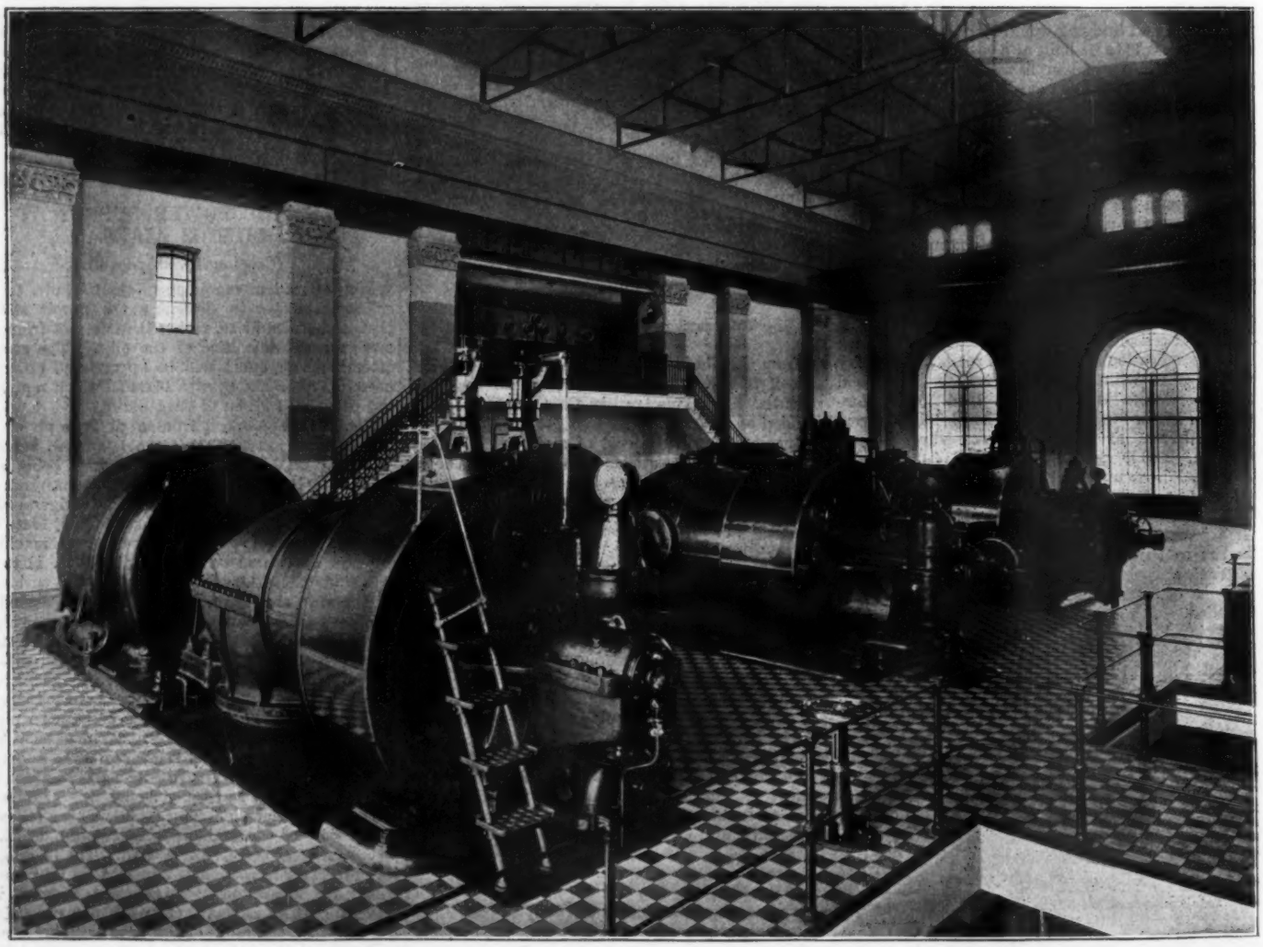


Fig. 10. Turbine Room with Three 5,000 Kw. Turbo-Generators.

ELECTRIC POWER SUPPLY AT BUENOS AIRES; PEDRO MENDOZA STATION.

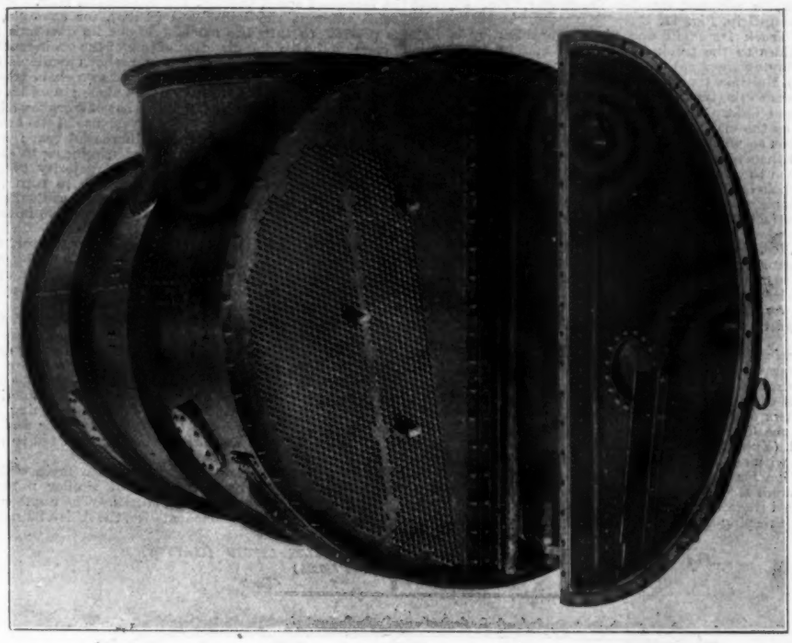


FIG. 23. CONDENSER.

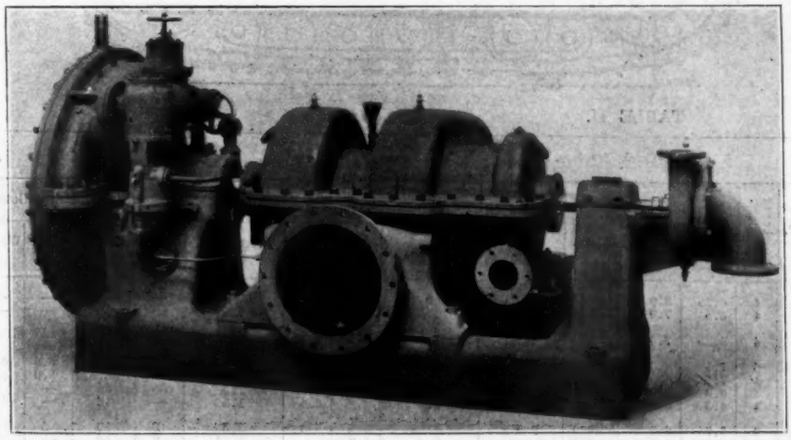


FIG. 24. TURBO-DRIVEN CIRCULATING PUMPS.

weights and controls the admission of oil to the relays provided above the valves leading to the nozzle chambers. The emergency governor is fitted just below the worm wheel on the main governor spindle, and when the speed exceeds a certain limit knocks out a pawl on the main stop-valve gear, and this valve then closes automatically under the pressure of a spring. The oil pump, which is of the gear-wheel type, is fitted at the foot of the governor spindle as indicated.

A section through the stop valve is shown in Fig. 13. As will be seen, there is a second valve between it and the steam chest. This valve is normally closed by a spring, and is opened by oil admitted under the piston shown at the top. The pressure of the oil admitted here is controlled by the main governor. The overload valve is represented in Fig. 14. It opens automatically when the oil pressure beneath its spring-loaded piston exceeds a predetermined limit. Provision is made as usual for adjusting the normal speed of revolution either by electric relay from the switchboard or by hand.

All steam for subsidiary services is taken from the steam chest of the turbine, the different supplies being indicated diagrammatically in Fig. 15, where the different branches, A to F, furnish steam to the reducing valve for the labyrinth packings, for the auxiliary steam-driven oil pump, and for different automatic valves. Of these the most important is that which puts the turbine "on atmosphere" in case of a condenser failure. A section through this valve is reproduced in Fig. 16. This valve, which is connected to the turbine exhaust by the flange on the right, is opened by live steam acting under the piston A, should the vacuum fail for any reason. It is recommended that to keep the valve in working order it should be turned round daily, and to facilitate this a cross-piece is fitted at the top of the spindle as indicated.

The working of the station is much facilitated by the adoption of oil fuel. Steam can be raised from the cold in 75 minutes, or if the boiler is already hot, the full working pressure can be attained in 10 minutes, starting from zero pressure.

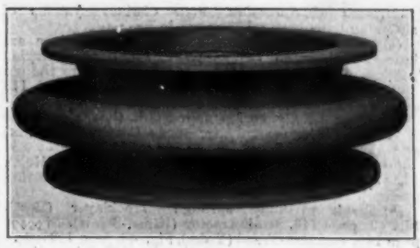


FIG. 25 STEAM PIPE EXPANSION PIECE.

The condenser is built up of steel plates and angles. Details of its construction are illustrated in Figs. 17 to 20, Plate XIII. It is 5.8 m. long between tube plates. The body diameter is 2.95 m. and the diameter of the exhaust branch is 2.2 m. A concertina-piece is used to connect the condenser with the turbine exhaust branch. The tubes are 1 in. in diameter, and are packed with tape in the usual way. Stout stays pass between the tubeplates and effectually stiffen these against collapse. A special feature of the condenser is the provision made for cleaning tubes, which will be best understood on reference to Fig. 23, annexed. The water box at each end of the condenser is divided into two entirely independent compartments by a vertical diaphragm. Owing to this construction the condenser is in effect constituted as two independent condensers, comprised within one and the same shell. Each of these has its own supply and discharge branches for the circulating water, and this supply may be cut off from either without affecting that to the other. By shutting off the water from the one side and swinging open the half cover as indicated in Fig. 23, the tubes on that side can be got at and cleaned whilst the other side is in full activity. The consequent reduction in the vacuum even with the turbine running at full output is not more than about 1 in. of mercury, whilst by arranging for the cleaning operation to be made when the turbine is working at not more than half-load the vacuum maintained is actually somewhat higher than in normal full-load running.

Steam turbine driven centrifugal pumps are used both for the circulating water and for removing the air and condensate. A set of condenser pumps mounted on the same shaft as the turbine driving them is illustrated in Fig. 24. The whole string is supported on but two ring-oiled bearings, the housings for which are cast solid with the bedplate. A water ejector is used to remove the air and is accommodated within the same casing as the circulating pump, its suction being connected to the discharge chamber of this pump. It thus receives its supply under the full head produced by the circulating pump. This arrangement requires but one suction gland and one pressure gland for the two pumps. The condensate pump is mounted outside the right-hand bearing, and as its impeller is overhung only one packing is required. Under normal conditions this pump can be arranged to deliver the condensate direct to the hot well without the use of an intermediate tank. The turbine used is of the one-stage type, velocity compounded, with three rows of moving blades per stage. The bearing adjacent to it is water-cooled by a supply derived from the circulating water pipe. The speed of the turbine is controlled by an hydraulic relay connected to the discharge pipe of the ejector pump. Should the pressure in this pipe fall the relay operates so as to increase the turbine speed. An independent runaway governor is also provided, which cuts off the supply of steam completely should the speed become excessive.

The ejector by means of which the air is withdrawn from the condenser is of simple construction. It requires for its operation about one-tenth as much water as the circulating pump.

(To be continued.)

TRACTION ON BAD ROADS OR LAND.*

By L. A. LEGROS, of Acton, Member.

(*Continued from page* 120.)

Methods of Springing.—Four distinct systems of springing have been tried or are in use :—

(*e*) Foot springs : In this method the springs are interposed between the actual foot and the carrying portion, Fig. 45, page 119 *ante* ; examples are the old and new forms of Pedrail (Diplock), Fig. 40, page 118 *ante*, and Fig. 44, page 119 *ante*.

(*f*) Track wholly spring supported, the axle of the track frame being carried on springs : Centiped (Phœnix) and Allis-Chalmers, Fig. 73 (to be given later).

(*g*) Track partly spring supported : Caterpillar (Holt), Fig 47 and Clayton tractor (totally over effective bearing portion), Fig. 48, on the present page.

(*h*) Track pivotally sprung : Tracklayer (Best), Fig. 49, page 146, Strait tractor (Killen-Strait), Fig. 50, page 146, and Ball-Tread (Yuba), Fig. 46, page 119 *ante*.

Owing to many constructional difficulties direct springing of the feet, Class (*e*), has not yet taken a prominent place among commercial chain-track tractors.

The methods of track springing are intimately associated with those adopted for ensuring equable load distribution on the chain.

The method of supporting the vehicle on springs carried on the track axle, Class (*f*), requires either a chain or a cardan drive to permit driving when the springs are unequally loaded, as when crossing ditches or running on side-lying ground.

In some vehicles of Class (*g*) the whole of the effective portion of the track is capable of vertical movement, as in the Clayton tractor, Fig. 48, in which a link connects the single truck frame to the track frame. In others the truck is in one or more parts controlled by linkwork from the back of driving-sprocket axle, a practice followed successfully by the Caterpillar (Holt), Fig. 47, page 119 *ante*.

In other tractors having chain-driven sprockets the whole of the track-frame is capable of pivoting about a central axle, an arrangement which is adopted in the Creeping-Grip tractor, Fig. 41, page 118 *ante* ; or the track-frame may be pivoted and sprung about the axle of the driving sprocket, as in the Tracklayer (Best), Fig. 49, and the Strait tractor (Killen-Strait), Fig. 50, page 146. These two arrangements, though very different in appearance, are both equivalent to partial springing of the track, Class (*h*).

Truck Frames and Track-Frame Connections.—The various methods adopted for distributing the load of the tractor over the chain-track elements may be classified as follows :—

(*j*) Truck frame and track frame identical ; this arrangement is adopted in the modern form of Pedrail, in the Strait, Fig. 50 ; Log-Hauler, Fig. 60 (to be given later) ; Centiped, Allis-Chalmers, Fig. 73 ; and Ball-Tread, Fig. 46, page 119 *ante*.

(*k*) Truck frame integral with track frame ; this form of construction, which very closely resembles the preceding, is adopted by the Tracklayer, Fig. 49, and Creeping-Grip, Fig. 41.

(*l*) Truck frame in one piece connected by a link or guides to the track frame ; this method is used in the Clayton tractor, Fig. 48.

(*m*) Multiple truck frame articulated and connected by links to the track frame ; this is adopted in the lower powered Caterpillar, Fig. 51, page 146, and enables the load on the chain track to be distributed over irregular surfaces to which the chain track and truck frames can adapt themselves under the action of the springs.

When the track frame is pivoted to the main framing, the whole length of supporting surface of the chain track is capable of adapting itself to long undulations or irregularities (see Fig. 69, to be given later) ; this arrangement is therefore very suitable for use on ordinary ground, snow, ice, sand or marsh. The articulated truck frame, on the other hand, permits a more even distribution of load over the chain-track elements when passing over small irregularities such as stones, rocks, railway ties, rails, &c., and for this reason is better adapted for haulage from railhead into country in which rock crops out.

Steering.—The arrangements adopted for steering vary considerably. In several models, of which the Centiped and Creeping-Grip are examples, there are steering wheels with steering of the ordinary Ackermann type ; in others the practice is to use a single steering wheel, as in the Caterpillar (Holt, 75 h.p.), Clayton and Ball-Tread (Yuba). The steering wheel of the Clayton is fitted with an elevating gear, so that it can be raised out of action for turning small circles. In the Strait there is a small steering chain track ; in some of the lower-powered tractors—Caterpillar (Holt, 45 h.p. and 18 h.p.), Baby Creeping-Grip (16 h.p.) and F. C. Austin (35 h.p. and 15 h.p.)—the tractor is carried entirely on the two tracks, and steering is effected by releasing the clutch on the inside of the curve to be taken, and driving only on the outside of the curve. In the Burford-Cleveland a brake is applied to one side and the other is driven at increased speed through the differential gear. With some tractors, the Ball-Tread (Yuba), for example, it is possible to turn the machine about its own axis by reversing the driving direction of one of the chain tracks.

It is obvious that there are four methods available for securing steering of tractors carried on two chain tracks only ; one by the use of the clutches alone ; another by supplementing the clutch action by that of a brake acting on the appropriate side ; a third by the use of the brake on one side and the action of a differential gear ; and the operation of an independent reversing gear to each track gives a fourth method. In the majority of the designs under consideration it is possible to turn the machine in a circle of about 15 ft. to 20 ft. radius, and in some of the small tractors the turning circle is only 6 ft. radius.

In the Log-Hauler (Phœnix) steam-driven tractor, for use on snow and ice, runners are fitted for steering (see Fig. 59, to be given later) ; these can also be arranged with some of the other types described when required to work under winter conditions.

Driving Gear.—The drive of some tractors is fitted with a differential gear ; this is usual where there is front-wheel steering, as in the Creeping-Grip or Centiped (Phœnix). In those machines in which steering is effected by declutching one or other of the tracks it is not usual to fit a differential ; where, however, the steering is effected or assisted by independent clutching or braking of the tracks, as in the Clayton tractor and in the Burford-Cleveland, a differential gear is fitted to the main drive between the tracks.

The driving gear generally comprises a main clutch and a change-gear box of somewhat similar pattern to that used on motor lorries or trucks. The number of speeds fitted varies. In one instance, the Allis-Chalmers,

* Paper read before the Institution of Mechanical Engineers, on Friday, January 18, 1918.

Fig. 48. CHAIN-TRACK TOTALLY SPRING-SUPPORTING OVER EFFECTIVE LENGTH (CLAYTON)
(FOR ENLARGED DETAILS SEE FIG. 95)

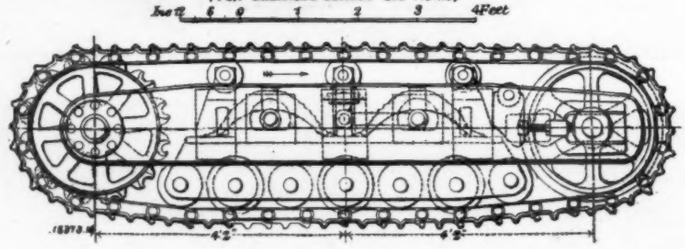


TABLE II.

Chain-Track Tractors.

No.	Fig.	Description.	Maker.	H.P.	Number of Cylinders.	Bore (in.).	Stroke (in.).	Rated r.p.m.	Main Clutch.	Speeds in m.p.h. at Normal Engine Revolutions. 1st.	2nd.	3rd.	Reverse.	Capacity : British Gallons. Petrol.	Paraffin.	Bulk Oil.	Water
1	59	Log-Hauler (steam)	Phœnix	100	4	6.25	8.0 d.a.	—*	Throttle	0	to	5.0	0 to 5.0	—	—	—	—
2	66	Centiped .. 50 h.p.	Phœnix	50	4	5.5	7.0	700	—	1.5	3.0	5.5	1.5	—	50	—	—
3	73	Tractor-Truck Type A	Allis-Chalmers	68	4	5.25	7.0	1,000	Cone	1.61	3.5	6.2†	1.41	21	—	—	9
4	74	Caterpillar .. 120 h.p.	Holt	120	6	7.5	8.0	550	5 disc	2.13	*(3.5)*	—	2.13	—	53.5	*5.0*	67
5	75	Caterpillar .. 75 h.p.	Holt	75	4	7.5	8.0	550	5 disc	2.13	3.5	—	2.13	—	53.5	5.0	44
6	76	Caterpillar .. 45 h.p.	Holt	45	4	6.0	7.0	625	5 disc	1.5	2.13	3.5	1.5	—	36	—	7
7	78	Caterpillar .. 18 h.p.	Holt	18	4	4.5	6.0	750	3 disc	1.5	2.2	3.6	1.5	—	12	—	4.2
8	92	Clayton Tractor 110 h.p.	Clayton and Shuttleworth	110	6	5.75	6.5	1,000	7 disc	1.25	3.5	5.0	2.0	2	12	5	12
9	100	Clayton Tractor 35 h.p.	Clayton and Shuttleworth	35	4	4.75	5.5	1,000	Cone	2.0	4.0	—	1.75	2	12	—	5
10	101	Tracklayer .. 90 h.p.	C. L. Best	90	4	8.0	9.0	450	Expanding	1.5	2.375	—	1.625	6	66	7	27
11	—	Tracklayer .. 75 h.p.	C. L. Best	75	4	7.75	9.0	450	Expanding	1.5	2.375	—	1.625	6	66	7	27
12	102	Tracklayer .. 30 h.p.	C. L. Best	30	4	5.25	6.25	600	Expanding	1.75	2.5	—	2.0	—	21	1.2	—
13	—	Tracklayer .. 16 h.p.	C. L. Best	16	4	4.375	5.25	650	Expanding	1.75 to *2.38*	—	—	1.75 to *2.38*	—	12.5	—	—
14	—	Creeping-Grip .. "Giant"	Bullock	75	4	7.5	9.0	550	Expanding	1.06	2.4	3.4	1.77	12	43	—	50
15	107	Creeping-Grip .. "Senior"	Bullock	50	4	6.5	8.0	600	Expanding	1.06	2.4	3.4	1.77	12	46	—	120
16	—	Creeping-Grip .. "Junior"	Bullock	30	4	5.0	7.0	600	Expanding	2.25	4.0	—	2.25 to 4.0	12	12	—	21
17	108	Creeping-Grip .. "Baby"	Bullock	16	2	6.0	6.0	550	Expanding	2.5	—	—	2.5	12.5	—	—	—
18	112	Austin Tractor No. 35	F. C. Austin	35	4	5.0	6.5	800	—	1.25	2.5	3.75	1.25 to 3.75‡	16.7	33.3	—	47
19	113	Austin Tractor No. 15	F. C. Austin	15	4	4.25	5.5	800	—	1.25	2.5	3.75	1.25 to 3.75‡	7.5	15	—	11.7
20	114	Burford-Cleveland Tractor ..	H. G. Burford	20	4	3.5	5.125	1,000	2 disc	3.2	—	—	3.2	2	6	—	10
21	110	Strait Tractor	Killen-Strait	50	4	4.75	6.75	850	Cone	2.0	3.0	—	2.0	25	—	2.5	12.5
22	110	Strait Tractor	Killen-Strait	50	4	4.75	6.75	850	Cone	2.0	3.0	—	2.0	25	—	2.5	12.5
23	122	Strait Tractor Mod. 3	Killen-Strait	25	4	4.25	5.75	900	Cone	2.25	—	—	2.25	10	—	2.5	7
24	124	Yuba Tractor .. Mod. 18	Yuba Ball-tread	35	4	5.25	5.75	700	—	1.96	3.05	—	1.96	4.5	22.5	3.2	—
25	124	Yuba Tractor .. Mod. 12	Yuba Ball-tread	25	4	4.5	5.5	700	—	1.64	2.66	—	1.64	3	15	1.3	—
26	137	Martin Cultivator 25 h.p.	Martin	25	4	3.75	5.0	1,000	Cone	3.0	—	—	3.0	7.5	—	—	—
27	147	Lefebvre Tractor 40 h.p.	Lefebvre	40	4	5.125	6.25	900	Disc	2.15	2.92	—	2.15	22	—	—	8.8
28	—	Lefebvre Tractor 30 h.p.	Lefebvre	30	4	4.375	5.125	1,000	Disc	2.15	2.92	—	2.15	22	—	—	6.6
29	152	Trench Excavator (steam) .. Mod. 60	Parsons	80	2	7.5	10.0 d.a.	175*	Expanding	0.002 to 0.045		1.5	1.5	—	—	—	170
30	153	Trench Excavator Mod. 48	Parsons	62	4	7.25	9.0	500	Band	0.004 to 0.055		1.375	1.375	43	—	—	170
31	—	Trench Excavator Mod. 36	Parsons	45	4	6.25	8.0	600	Band	0.004 to 0.055		1.5	1.5	38	—	—	136
32	154	Trench Excavator Mod. 24	Parsons	30	4	5.0	7.5	650	Band	0.008 to 0.110		1.5	1.5	27.5	—	—	89
33	—	Trench Excavator Mod. 18	Parsons	20	4	5.0	6.0	700	Band	0.008 to 0.110		1.5	1.5	21.5	—	—	39
34	—	Trench Excavator Mod. 15	Parsons	30	4	5.0	7.5	650	Band	—	—	1.5	1.5	27.5	—	—	89

Approximate and estimated figures are shown in italics. * Steam. † 4th Speed 7.5. ‡ 3 Speeds on reverse.

DETAILS OF CHAIN TRACK TRACTORS.

TABLE II.—(*continued.*)

Chain-Track Tractors.

No.	Fig.	Description.	Maker.	Supports to Each Track.	Track Width. Normal.	Track Width. Wide.	Track Length.	Area of Tracks. Normal.	Area of Tracks. Wide.	Weights (lb.) carried on Tracks. Normal.	Weights (lb.) carried on Tracks. Wide.	Weights (lb.) carried on Steering Wheels.	Total Weights (Lb.). Normal.	Total Weights (Lb.). Wide.	Insistent Weight in Lb. per Square Inch. Normal.	Insistent Weight in Lb. per Square Inch. Wide.
					in.	in.	in.	sq. in.	sq. in.	Normal.	Wide.		Normal.	Wide.	Normal.	Wide.
1	59	Log-Hauler (steam)	Phœnix	14 rollers	12.0	—	60	1,440	—	30,500	—	5,500	36,000	—	21.18	—
2	66	Centiped .. 50 h.p.	Phœnix	14 rollers	12.0	—	60	1,440	—	13,600	—	3,200	16,800	—	9.45	—
3	73	Tractor-Truck Type A	Allis-Chalmers	15 rollers	12.5	—	60	1,500	—	*14,400*	—	*3,600*	18,000	—	*9.60*	—
4	74	Caterpillar .. 120 h.p.	Holt	5 wheels	24.0	30.0	80	3,840	4,800	23,750	—	2,500	26,250	—	6.19	4.95
5	75	Caterpillar .. 75 h.p.	Holt	5 wheels	24.0	30.0	80	3,840	4,800	21,350	—	2,250	23,600	—	5.56	4.45
6	76	Caterpillar .. 45 h.p.	Holt	5 wheels	13.0	30.0	70	2,080	4,800	13,000	14,500	—	13,000	14,500	6.25	3.02
7	78	Caterpillar .. 18 h.p.	Holt	5 wheels	11.0	—	64	1,408	—	6,000	—	—	6,000	—	4.26	—
8	92	Clayton Tractor 110 h.p.	Clayton and Shuttleworth	7 wheels	22.5	—	100.5	4,522	—	26,880	—	3,360	30,240	—	5.94	—
9	100	Clayton Tractor 35 h.p.	Clayton and Shuttleworth	4 wheels	14.0	—	71.3	2,000	—	5,040	—	—	5,040	—	2.52	—
10	101	Tracklayer .. 90 h.p.	C. L. Best	7 wheels	24.0	30.0	90	4,320	5,400	*25,000*	*25,000*	*5,000*	*30,000*	*30,000*	*5.79*	*4.63*
11	—	Tracklayer .. 75 h.p.	C. L. Best	5 wheels	24.0	30.0	66	3,168	3,960	*23,300*	*23,300*	*4,700*	*28,000*	*28,000*	*7.36*	*5.88*
12	102	Tracklayer .. 30 h.p.	C. L. Best	4 wheels	12.0	20.0	66	1,584	2,640	8,500	8,500	—	8,500	8,500	5.37	3.22
13	—	Tracklayer .. 16 h.p.	C. L. Best	3 wheels	10.0	—	66	1,320	—	5,100	—	—	5,100	—	3.86	—
14	—	Creeping-Grip.. 75 h.p.	Bullock	4 wheels	20.0	—	64	2,560	—	19,500	—	3,500	23,000	—	7.62	—
15	107	Creeping-Grip.. 50 h.p.	Bullock	4 wheels	20.0	—	64	2,560	—	*16,500*	—	*3,000*	*19,500*	—	*6.45*	—
16	—	Creeping-Grip.. 30 h.p.	Bullock	3 wheels	12.0	—	48	1,152	—	6,500	—	*1,500*	*8,000*	—	*5.84*	—
17	108	Creeping-Grip.. 16 h.p.	Bullock	3 wheels	12.0	—	48	1,152	—	5,200	—	—	5,200	—	4.51	—
18	112	Austin Tractor 35 h.p.	F. C. Austin	6 wheels	12.0	36.0	96	2,300	6,900	10,800	12,300	—	10,800	12,300	4.70	1.78
19	113	Austin Tractor 15 h.p.	F. C. Austin	2 wheels	12.0	—	60	1,440	—	6,750	—	—	6,750	—	4.70	—
20	114	Burford-Cleveland 20 h.p.	H. G. Burford	3 wheels	6.0	—	50	600	—	3,000	—	—	3,000	—	5.00	—
21	119	Strait Tractor 50 h.p.	Killen-Strait	3 wheels	18.0	24.0	48	1,728	2,304	*8,000*	*8,000*	*1,500*	9,500	*9,500*	4.63	*3.47*
22	119	Strait Tractor 50 h.p.	Killen-Strait	3 wheels	30.0	36.0	48	2,880	3,456	*8,500*	*8,500*	*1,500*	*10,000*	10,000	*2.95*	2.46
23	122	Strait Tractor 25 h.p.	Killen-Strait	3 wheels	17.0	—	48	816	—	*3,000*	—	*1,000*	6,000*	—	*3.68*	—
24	124	Yuba Tractor.. 35 h.p.	Yuba Ball-tread	2 × 21 balls	17.0	—	48	1,632	—	7,400	—	1,500	8,900	—	4.53	—
25	124	Yuba Tractor.. 25 h.p.	Yuba Ball-tread	2 × 16 balls	15.0	—	36	1,080	—	6,000	—	1,600	7,600	—	5.55	—
26	137	Martin Cultivator 25 h.p.	Martin	3 wheels	8.0	—	40	640	—	3,250	—	670†	3,920	—	5.01	—
27	147	Lefebvre Tractor 40 h.p.	Lefebvre	Not supporting	10.2	—	63	—	—	—	—	4,000	7,050	—	—	—
28	—	Lefebvre Tractor 30 h.p.	Lefebvre	Not supporting	8.3	—	51	—	—	—	—	1,780	5,950	—	—	—
29	152	Trench Excavator Mod. 60	Parsons	6 wheels	26.0	—	72	3,744	—	27,000	—	27,000‡	54,000	—	7.21	—
30	153	Trench Excavator Mod. 48	Parsons	6 wheels	27.5	—	72	3,960	—	33,800	—	11,200	45,000	—	8.54	—
31	—	Trench Excavator Mod. 36	Parsons	6 wheels	26.0	—	66	3,432	—	22,000	—	8,000	30,000	—	6.41	—
32	154	Trench Excavator Mod. 24	Parsons	6 wheels	25.5	—	62	3,162	—	12,000	—	5,000	17,000	—	3.80	—
33	—	Trench Excavator Mod. 18	Parsons	6 wheels	24.0	—	41	1,968	—	7,000	—	2,600	9,600	—	3.56	—
34	—	Trench Excavator Mod. 15	Parsons	9 wheels	30.0	—	78	4,680	—	20,000	—	—	20,000	—	4.27	—

Approximate and estimated figures are shown in italics. * 2,000 lb. on wheel. † On ploughs. ‡ Two pairs of wheels.

TABLE II.—(*concluded.*)

No.	Fig.	Description.	Maker.	Steering Gear.	Tractor Overall. Normal Width.	Tractor Overall. Length.	Turning Radius.	Drawbar Pull on Low Gear.	Front Wheels. No.	Front Wheels. Width.	Front Wheels. Diam.	Pitch of Chain Track.	Drawbar Pull Per Cent. of Weight. Normal.	Drawbar Pull Per Cent. of Weight. Wide
					ft. in.	ft. in.	ft. in.	lb.		in.	in.	in.	Normal.	Wide
1	59	Log-Hauler (steam)	Phœnix	Runners and engines	5 4	27 6	75 0	—	2	runners		*9.5*	—	—
2	66	Centiped .. 50 h.p.	Phœnix	Front wheels	*5 4*	21 0	25 0	8,000	2	10	40	*9.5*	47.6	—
3	73	Tractor-Truck Type A	Allis Chalmers	Front wheels	*5 6*	*21 6*	*26 0*	8,000	2	10	40	7.6	44.4	—
4	74	Caterpillar .. 120 h.p.	Holt	Front wheel and clutches	8 8	21 0	*16 0*	12,000	1	18	36	*9.25*	45.7	—
5	75	Caterpillar .. 75 h.p.	Holt	Front wheel and clutches	8 8	19 6	15 0	8,500	1	18	36	*9.25*	36.0	—
6	76	Caterpillar .. 45 h.p.	Holt	Clutches and brakes	6 8	12 9	6 0	4,500	none	—	—	*9.25*	34.6	31.0
7	78	Caterpillar .. 18 h.p.	Holt	Clutches	4 3	9 6	6 0	2,800	none	—	—	*7.5*	46.7	—
8	92	Clayton Tractor 110 h.p.	Clayton and Shuttleworth	Front wheel and brakes	7 4	17 6	10 0	22,000	1	6	50	7.75	72.8	—
9	100	Clayton Tractor 35 h.p.	Clayton and Shuttleworth	Clutches and brakes	5 4	10 10	7 0	—	none	—	—	7.5	—	—
10	101	Tracklayer .. 90 h.p.	C. L. Best	Front wheel and clutches	*8 9*	*24 6*	—	14,500	1	20	40	9.75	48.3	—
11	—	Tracklayer .. 75 h.p.	C. L. Best	Front wheel	8 7	22 4	—	12,000	1	24	48	9.75	42.9	—
12	102	Tracklayer .. 30 h.p.	C. L. Best	Clutches and brakes	5 5	9 4	6 0	3,500	none	—	—	7.25	41.2	—
13	—	Tracklayer .. 16 h.p.	C. L. Best	Clutches and brakes	4 2	7 0	5 0	1,750	none	—	—	4.6	34.3	—
14	—	Creeping-Grip.. 75 h.p.	Bullock	Front wheels	8 0	18 8	30 0	13,000	2	10	40	9.0	56.5	—
15	107	Creeping-Grip.. 50 h.p.	Bullock	Front wheels	8 0	18 0	30 0	8,200	2	10	40	*9.0*	42.1	—
16	—	Creeping-Grip.. 30 h.p.	Bullock	Front wheel	5 8	13 0	22 0	3,330	1	14	32	*7.0*	41.6	—
17	108	Creeping-Grip.. 16 h.p.	Bullock	Clutches*	5 3	11 6	8 0	—	none	—	—	*6.0*	*30.6*	—
18	112	Austin Tractor 35 h.p.	F. C. Austin	Clutches and brakes	5 8	10 0	6 0	5,400	none	—	—	*9.0*	50.0	43.9
19	113	Austin Tractor 15 h.p.	F. C. Austin	Clutches and brakes	6 0	9 0	6 0	3,000	none	—	—	*9.0*	44.4	—
20	114	Burford-Cleveland 20 h.p.	H. G. Burford	Band brakes	4 2	8 0	6 0	*2,000*	none	—	—	8.0	*66.7*	—
21	119	Strait Tractor 50 h.p.	Killen-Strait	Front track	6 0	13 0	8 0	5,600	1	14	chain track	6.5	59.0	*59.0*
22	119	Strait Tractor 50 h.p.	Killen-Strait	Front track	8 0	13 0	8 0	5,600	1	14	chain track	6.5	*56.0*	56.0
23	122	Strait Tractor 25 h.p.	Killen-Strait	Front track	5 10	12 10	8 0	*2,500*	1	12	chain track	6.5	41.7	—
24	124	Yuba Tractor.. 35 h.p.	Yuba Ball-tread	Front wheel*	6 1	15 1	7 6	4,600	1	14	36	*3.75*	51.7	—
25	124	Yuba Tractor.. 25 h.p.	Yuba Ball-tread	Front wheel*	5 9	14 7	7 9	3,400	1	14	36	*3.75*	44.7	—
26	137	Martin Cultivator 25 h.p.	Martin	Dog clutches	4 6	16 0†	8 0	*1,900*	none	—	—	7.0	48.5	—
27	147	Lefebvre Tractor 40 h.p.	Lefebvre	Front wheels	6 1	18 0	16 6	4,400	2	10	30	8.5	62.4	—
28	—	Lefebvre Tractor 30 h.p.	Lefebvre	Front wheel	*5 9*	15 8	11 6	3,100	1	14	30	8.5	52.0	—
29	152	Trench Excavator Mod. 60	Parsons	Front and back wheels	10 0	35 0	30 0	—	2‡	14	40	7.0	—	—
30	153	Trench Excavator Mod. 48	Parsons	Front wheels	10 5	46 6	50 0	—	2	20	40	6.0	—	—
31	—	Trench Excavator Mod. 36	Parsons	Front wheels	8 9	36 6	50 0	—	2	20	34	6.0	—	—
32	154	Trench Excavator Mod. 24	Parsons	Front wheels	7 8	28 3	30 0	—	2	15	30	6.0	—	—
33	—	Trench Excavator Mod. 18	Parsons	Front wheels	7 0	23 0	30 0	—	2	15	26	5.0	—	—
34	—	Trench Excavator Mod. 15	Parsons	Clutches	10 0	15 0	30 0	—	none	—	—	6.0	—	—

Approximate and estimated figures in italics. * Either track can be reversed. † Includes ploughs. ‡ Also two back wheels.

there are four forward speeds and a reverse; in a few tractors three forward speeds and a reverse are fitted; two forward speeds and a reverse are more usual; very rarely, as in the high-power Caterpillar (Holt, 120 h.p.), only a single forward speed and reverse is ordinarily fitted, the two-speed gear being an alternative arrangement.

Chain Tracks.—The design of the chain track itself is one of the most important factors of the success or failure of the tractor. The chain track is usually driven by a sprocket at the back end, and passes round an idler at the front carried on the track frame and engaging only laterally with the chain track by a central flange or flanges; the idler axle is usually fitted with an adjustment for taking up wear of the chain track. It will be noted from the cross-sections shown that the width of the track is greater than the width of bearing for the rollers, and any hard object, rock or rail, encountered by the chain may therefore tend to load it unequally, and subject it to torsional stress. Furthermore, if the chain track passes over a hard and narrow object, such as a railway rail, this will tend to produce reverse curvature in any unsupported portion of the chain. This is particularly the case where the chain has a short free length between the leading idler wheel and the first pair of carrying rollers. Realisation and over-estimation of these difficulties were probably responsible for the early designs of chains made in this country.* The links were so arranged that the connecting pins were raised several inches from the ground, and the blocks, of which the chain track was composed, were so made as to butt against each other when the chain track was in the position of minimum curvature. In this way the bearing portion of the chain track formed an inverted arch, which was supported at portions of its length by the rollers, and depended on contact between the links for carrying the load on intermediate portions of the chain, as shown in Fig. 52. In order to reduce the stresses still further, and to relieve the chain pins of the heavy load to which they would otherwise be subjected, interlocking extensions above the pins were formed on the chain links. Unfortunately this method of carrying the load resulted in the introduction of new and greater difficulties, generally known as nut-cracker action. If the track worked only on sand or mud, or even on pure clay, there would be no difficulty; but where there is a combination of stones and clay or when, in crossing gravel or roads, any hard object can be picked up by the track and get between the bearing faces of the links, the stresses so caused become excessive and the track may even become jammed. This result can be caused also by pieces of fencing wire or scrap iron such as may occasionally be picked up on a farm. In the forms of chain track now commonly used the pin centres are brought as close to the ground level as possible, and the chain plates are so formed as to shield the opening between the track plates over the working range, as will be seen from Figs. 89 and 95, to be given later.

The second source of trouble to which chain tracks are subject is that of stretching due to wear. This lengthens the pitch of the chain and necessitates fitting and adjusting gear to take up the slack; it also tends to cause riding on the driving sprocket. As it is usual to pitch the chain pins so widely that they will engage with alternate teeth of the driving wheel, when cut as an ordinary sprocket, this wheel should have an odd number of teeth in order to distribute the wear uniformly over the whole of the teeth.

The chain-track links have three functions to perform:—

1. Carrying the load.
2. Affording the necessary resistance for traction by engaging with the ground surface, and

* See Historical Note, Appendix I.

Fig. 49. CHAIN-TRACK FRAME WITH PIVOTAL-SPRINGING ABOUT BACK AXLE (TRACKLAYER).

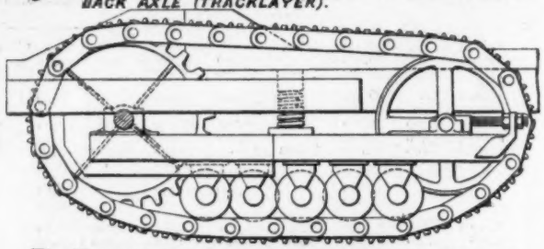
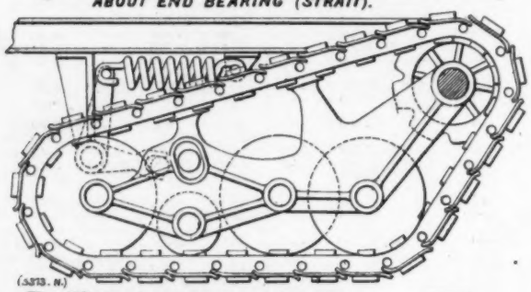
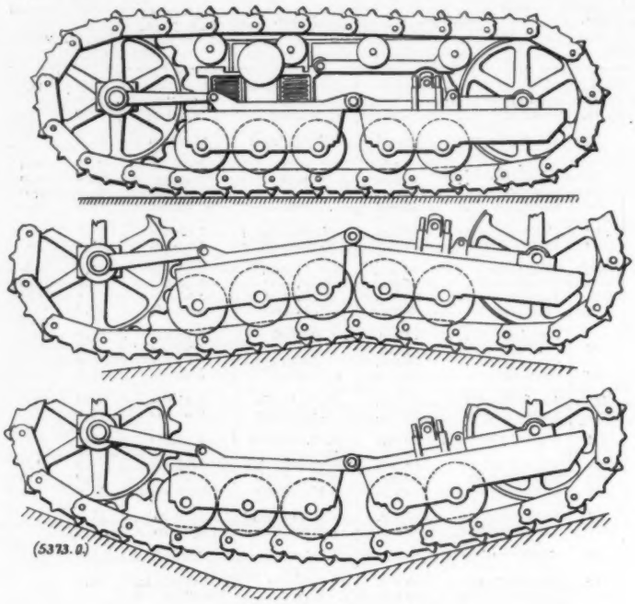


Fig. 50. CHAIN-TRACK FRAME WITH PIVOTAL-SPRINGING ABOUT END BEARING (STRAIT).



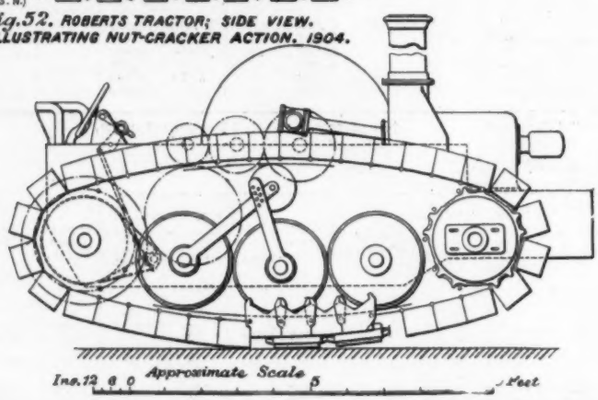
(5373. H.)

Fig. 51. MULTIPLE-ARTICULATED TRUCK-FRAME (CATERPILLAR) (FOR COMPLETE VIEW, SEE Fig. 91.)

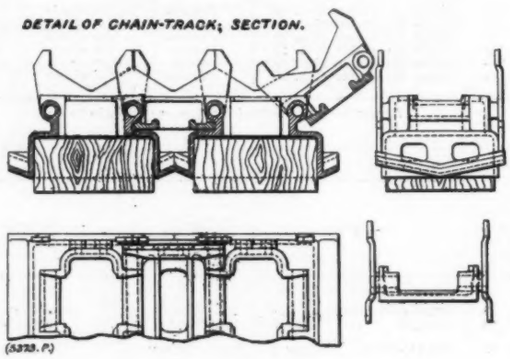


(5373. I.)

Fig. 52. ROBERTS TRACTOR; SIDE VIEW. ILLUSTRATING NUT-CRACKER ACTION. 1904.

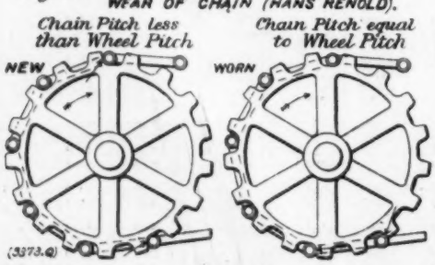


DETAIL OF CHAIN-TRACK; SECTION.



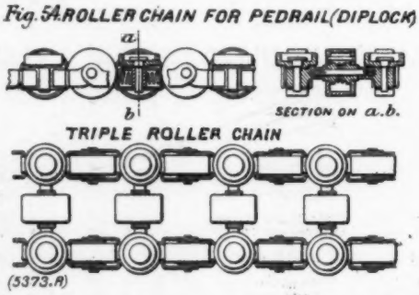
(5373. P.)

Fig. 53. SPROCKET DESIGN TO ALLOW FOR WEAR OF CHAIN (HANS RENOLD).



(5373. Q.)

Fig. 54. ROLLER CHAIN FOR PEDRAIL (DIPLOCK)



(5373. R.)

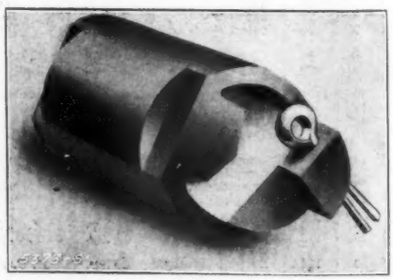


FIG. 55. THE "BEST" DRIVING CHAIN PIN.

3. Providing the gearing pin, or its equivalent in tooth form, to engage with the driving sprocket.

The first condition involves a machined surface, preferably hardened, for the carrying rollers to bear on. The second condition necessitates an irregular outline of the lower surface of the link, so that it can gear with the ground surface as a large pinion would gear into a rack; hence the form of shoe must approximate to a ribbed section, and is usually of pressed steel. The third condition requires that the pin joints or gear faces shall be machined accurately enough to work smoothly with the driving sprocket without risk of riding on its teeth. These three conditions, coupled with the proximity of the connecting pin to the ground, have limited the best designs to built-up forms of construction in which the actual link is a machined steel casting riveted to a pressed steel sole plate. The conditions of running require that this plate shall be of such form as to clear the end of the next plate throughout the range of inclination to which the links are subjected, and that over the same range there shall be no opening between the plates, in which nut-cracker action can take place (compare Figs. 48 and 52). The troubles due to stretching can be forestalled, as was shown by Hans Renold about twenty-five years ago, by making the pitch of the driving wheel large in the first instance, so that the chain track is driven, at the beginning of its life, from a tooth a camber about equivalent to that of a 16-ft. wheel.† In the majority of the tractors described the curvature of the supporting portion of the chain track is very small, corresponding to that of wheels from 90 ft. to 160 ft. in diameter, and in some cases even it has zero value, the part of the chain track on which the wheels run being laid flat. This necessitates care in keeping the chain track constantly adjusted for wear. It will be noted that this difficulty is not so serious in the chain tracks fitted with an intermediate chain, as both the chains can sag together, and it is possible to provide deep retaining faces to keep the intermediate roller chains in place.

The lateral pressure on the chain track when the tractor is travelling on side-lying ground, or crossing ditches obliquely, is another factor that must be taken into account in designing the chain track as well as the truck frame and its connections. Under most conditions the sideway thrust is taken partly on the flanges of the truck rollers and partly on the flanges of the driving sprocket and idler. An arrangement which appears to provide specially for this condition is that of the Ball-Tread (Yuba), Fig. 46, page 119 *ante*. In this the whole of the lateral as well as the vertical pressure is transferred from the chain track to the track frame through the balls. Lateral load merely affects the angle of incidence of pressure on the ball without increase of friction.

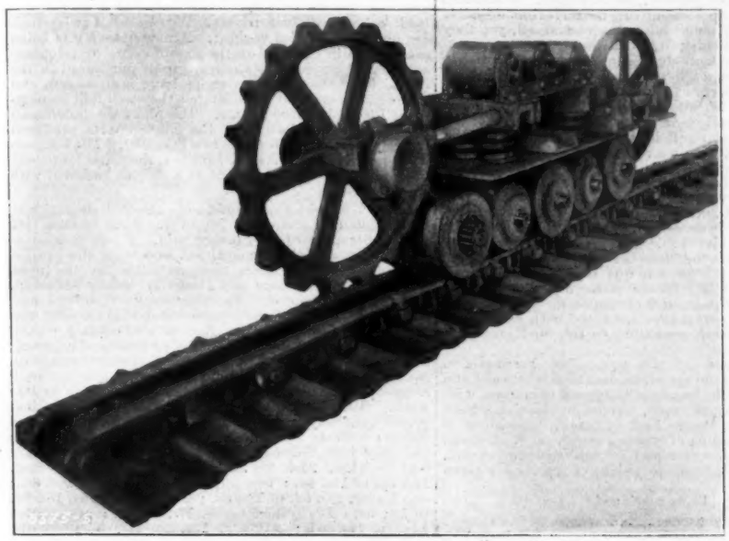


FIG. 56. PRESSED STEEL SHOE.

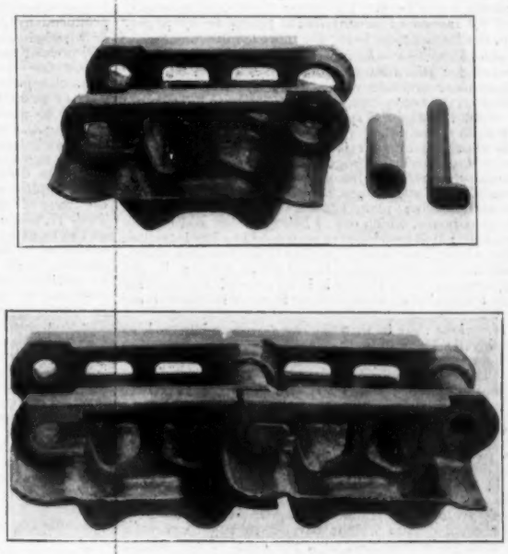


FIG. 57. SINGLE STEEL-CASTING SHOE.

nearly opposite that which is entering into engagement with it, Fig. 53. By these means a fairly long life can be assured to the chain, provided it is not overloaded, and that efficient lubrication is maintained. The usual method is to supply a large amount of low-grade oil to the inside of the chain; an oil drip so fitted to the side chains of certain early-pattern motor cars (1900–1902), which ran under almost identical conditions of mud and dust, has proved almost as efficient in preserving the chains as frequent removal, washing in paraffin, drying and soaking in a bath of warm tallow and plumbago. Cheap oil used lavishly appears, in fact, to keep the tracks from cutting or seizing even under very bad conditions. In the Tracklayer (Best) a different method of providing against wear is adopted, the pin being made of rocker form, Fig. 55, page 146.

Another matter that affects the design of the whole chain track is that of the permissible sag. The chain is supported laterally by the sprocket teeth at the back end and by the idler rim at the front end; over the intermediate parts it is only supported by the flanges of the supporting rollers. As the flanges of these rollers are limited for size by the closeness of the bearing surface to the ground, it will be seen that the permissible sag which may occur when crossing holes in rough ground is not very great. If supported at the ends the suspended portion of chain hanging freely will assume a curve which approximates to a catenary. For such a crude approximation as is afforded by the few suspended links of the chain track, the curve passing through the centres of the pins is very nearly a parabola; if the curvature is small, this in turn approaches a circular arc. The worst condition for the chain occurs when there is a combination of steering and backing on rough ground; this may at the same time cause slackness in the carrying part of the chain combined with sideway thrust due to steering, and, in some of the forms of construction described the roller flanges may be caused to ride on the chain surfaces.

One method of dealing with the difficulty is that of giving a large camber to the supporting portion of the track. In a vehicle styled the "Centipede," built by William Foster and Co., Limited,* the track was given

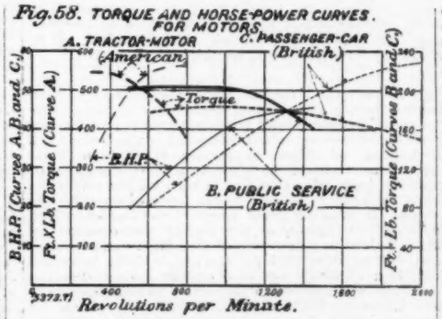


Fig. 58. TORQUE AND HORSE-POWER CURVES FOR MOTORS.

Diplock, in his recent developments of the Pedrail, has obtained the same result in a different way, by using a compound chain of rollers arranged alternately with axes horizontal and vertical, the track frame and bearing surfaces of the chain track being made with appropriate faces for receiving the vertical and lateral loads respectively, Fig. 54.

Track Shoes.—For travelling on rough country and under general agricultural conditions the pressed steel shoe is found satisfactory (see Fig. 56, annexed). In this case the supporting surface for the rollers consists of a steel casting, or case-hardened drop-forging, bolted to the shoe; in other cases the track shoe and supporting surface are formed in one as a single steel casting, Fig. 57, subjoined. Where the ground surface presents small resistance to shear, or actually lubricates the shoes, as is the case with clay and chalk and some grass surfaces, it is sometimes found necessary to attach grousers or spuds of angle bars to the shoes by means of bolts. When the tractor is required to do hauling on ordinary roads it may be necessary to attach thin sleepers of hard wood to the shoes in order to provide a flat bearing and prevent damage to the road surface. Those chain tracks which present fairly flat surfaces to the road and are not excessively cambered—the lower-powered Caterpillars, Clayton, and Burford-Cleveland for example—can be run over inferior roads with even less risk of damage than would occur with the ordinary driving slats of the common traction engine.

Engines.—The internal-combustion engines fitted to chain-track tractors are generally of a type resembling that used for heavy lorry or truck work. There is no reason for great economy in weight, and indeed the weight of the vehicle must not be too small for the tractive effort; consequently cast-iron is preferred to aluminium for the engine and also for the gear-box. A governor is usually fitted to prevent racing the engine. That care which is taken in designing the passenger-car engine to obtain a flat torque curve, and which is accompanied by large diameters of valves, induction and exhaust passages, is not called for here. The torque curve consequently falls rapidly at a comparatively low speed. This, as is generally recognised by the makers of engines for commercial vehicles, is not without advantage, for when the resistance to traction becomes unduly heavy, owing to gradient or softness of the ground, and the speed of the engine is consequently reduced, the torque increases and the driver has a better chance of extricating the vehicle from its difficulty without changing gear than is the case with constant torque. A typical torque curve of one of these engines is given in Fig. 58. The tractor engine runs at a low piston speed, 600 ft. to 900 ft. per minute; that is, at barely one-half the speed usual for the passenger-car engine. On the other hand, it is required to work at a greater percentage of its full power than is the case with the passenger-car engine, and for considerations of fuel economy it should, in general, be designed to give its best efficiency, measured in brake horse-power per gallon per hour, at from 50 per cent. to 70 per cent. of its full rated capacity. In many instances the engines are designed to start on petrol (gasolene) and to run normally on paraffin, or, in America, on "distillate";* this also implies a larger engine for the power than is the case where petrol or benzole is the usual fuel.

Lubrication of the engine is usually ensured by the splash system, but in some instances a combined splash and forced lubrication system is fitted. Separate oil reservoirs are of course required for the engine-lubricating oil and for the crude black oil used for the track chains.

Ignition and Starting.—The usual form of ignition is the high-tension magneto. Self-starters are not fitted, as they would involve too much additional complication. Owing to the large size of some of these engines, and the difficulty of starting by swinging the starting crank handle, a trip gear is arranged on the magneto which enables a strong sparking current to be obtained for a small movement of the cranking handle. This arrangement was used by the author in 1895 on gas-traction tram cars, the engines of which were started by pulling over the flywheel. The combined use of petrol for starting and paraffin for running complicates the carburettor and piping arrangements slightly, and involves

* *The Implement and Machinery Review*, November 1, 1914, page 888. The text describes the vehicle as being "carried" on 20 turned steel wheels 16 in. in diameter, but the illustration shows only four axles for carrying wheels, corresponding to 16 wheels. Moreover the power is given as 60 brake horse-power at 1,000 r.p.m., the low speed as 2 m.p.h., and the drawbar pull only 4,000 lb., which correspond to an overall mechanical efficiency of about 35.5 per cent.

† The radius of curvature of the track of the experimental tractors made in England about 1904 was also about 16 ft.

* "Distillate" is a low-grade spirit about 0.770 to 0.780 density.

fitting an extra tank, but the advantage of ease in starting is well worth this.

Radiators.—The radiators of chain-track tractors have been designed to meet the exigencies of the working conditions. The cooling surface must be large to enable the engine to run continuously under heavy load in the heat of summer; and a fan, if fitted, must be easy of access and simple in its driving gear. The water supply carried must be sufficiently large to last for a long journey of perhaps a whole day away from the base station; for this reason a large tank for water, or equivalent radiator capacity, is provided in most models. Finally, it is necessary that the whole water system should be capable of being drained at its lowest points, to avoid risk of damage by frost when the machine is laid up in winter.

As the machines have to work in places distant from large manufacturing centres, it is moreover advisable that the design of radiator should admit of its easy removal from the vehicle, of ready access of its water joints, and of the possibility of executing repairs without special tools and appliances. The conditions of the problem are similar to those of the motor omnibus; more severe regarding the total cooling to be effected, and less severe in weight restrictions. The type generally adopted is the vertical gilled tube with top and bottom reservoirs; in some of the lower-power tractors these reservoirs are made of sufficient size to avoid fitting a separate water tank. The water circulation is usually forced by means of a centrifugal pump or by a gear pump, the former type being the more common.

Speed of Tractors.—At normal revolutions per minute of the engine the lowest or first speed of the majority of chain-track tractors varies from 1.25 m.p.h. to 2.25 m.p.h.; on the second speed from 2 m.p.h. to 3.5 m.p.h.; and on the third or top speed, where such is fitted, from 3 m.p.h. to 5.5 m.p.h.

The changing of gear is usually effected by sliding gears or dog-clutches in a gear-box of motor-lorry type, the main clutch being disengaged for gear changing or reversing. Cut steel gears, case-hardened, are usual for spurs and bevels; plain bearings are commonly fitted in the gear-boxes, which are of heavy design and usually of cast-iron; ball bearings are only used in a few instances In the Caterpillar and Creeping-Grip tractors transmission to the back axles is by chain drive; in the Tracklayer and Ball-Thread it is by spur pinions gearing into an internal gear wheel formed in one with the driving sprocket.

It is curious that in these heavy slow-moving vehicles the epicyclic form of gear-change, usual on American passenger cars, should have found no practical application. This is the more remarkable as the difficulty of gear changing with sliding gears or dog-clutches is greater with governed engines.

Drawbar Pull.—Chain-tractor makers are nearly unanimous in their estimates of the loss of power that takes place between the engine and the ground. The power delivered at the track is estimated at from 70 per cent. in the large 100-h.p. tractors down to 55 per cent. in the small tractors of 30-h.p. and under. The force required to haul the track itself apparently varies from 15 per cent. of the weight carried in the fixed-roller type with plain bearings, to 2 per cent. of the weight carried in the travelling-roller type of track, or its equivalent.

The difference between the two constructions in loss of tractive effort may be attributed in part to the fact that it is easier to ensure efficient lubrication in a roller system that is loaded intermittently, than in one which is subjected to continuous load in one direction.

The comparatively heavy resistance to traction in those chain-track tractors in which the load is carried through rollers running on fixed axles is reduced in some cases by fitting roller bearings, of the Hyatt pattern for instance, on the roller-wheel shafts. These do not, however, reduce the lateral friction on the flanges and bosses of these wheels, which depends on the supply of grease that can be forced in through the pins by lubricators of the Stauffer type. Roller bearings so fitted will, of course, reduce the starting effort; nevertheless, it appears to the author that, of the several sources of friction contributing to losses in the chain tracks, the lateral friction of parts of the system of carrying rollers, where the rollers revolve on fixed axles, probably accounts for more than half the total loss of tractive effort.

Experience, gained in comparative tests of the fixed axles and roller-chain systems made over a long period under the same working conditions, will be necessary to determine the cost of upkeep of each; the same tests will also show how far the extra complication of the intermediate travelling chain of rollers is compensated by reduction in fuel consumption.

Climbing Power.—The drawbar pull varies in different types of vehicle from 30 per cent. to over 70 per cent. of the weight of the vehicle; a heavy tractor weighing 28,000 lb. can exert a drawbar pull of 12,000 lb.; a small tractor of 30 h.p. can exert a pull of 3,500 lb. The steepness of gradient that these vehicles can climb is consequently very great.

On railway gradients are measured as the tangent of the angle of inclination, the rise being referred to the plan of the track. In the case of hill-climbing tests of automobiles the maximum gradient climbed rarely exceeded 1 in 3; for this value of the tangent, the angle with the horizontal is 18 deg. 26 min., of which the sine is 0.3162; that is to say, the actual length of the road, in elevation, is about 5 per cent. more than that given in plan. As some chain-track tractors are capable of climbing a gradient as steep as 45 deg., it is necessary to refer climbing and haulage problems to the actual road length, which for an inclination of 45 deg. is over 40 per cent. greater than the length in plan. Thus a vehicle capable of exerting a draw-bar pull equal to 50 per cent. of its weight can climb a slope of 30 deg. provided that the ground present sufficient adhesion; and a vehicle capable of exerting a drawbar pull equal to 71 per cent. of its weight can climb a slope of 45 deg. provided that a sufficient bite can be obtained by the tracks on the surface.

The tractive effort for ordinary railway practice at speeds not exceeding 5 m.p.h., and therefore free from questions of air resistance, varies between 9 lb. per ton (0.4 per cent.) for the train hauled, and 12.5 lb. per ton (0.55 per cent.) for the train including engine and tender; on tramway rails the tractive effort varies from 30 lb. per ton (1.34 per cent.) wet, to 56 lb. per ton (2.5 per cent.) dry; or ordinary roads the effort varies from 70 lb. per ton (3.1 per cent.) on macadam to 120 lb. per ton (5.4 per cent.) on good gravel roads, and it is much more on bad gravel roads and across fields. The inclination of the ground on which chain-track tractors will roll back varies from 1 in 7 for the fixed-axle plain-bearing roller type, to 1 in 50 for the independent roller chain or its equivalent.

In comparing chain-track tractors with other vehicles for resistance to traction it must, however, be remembered that the resistance with fixed roller tracks, which may amount to 14 per cent. for the tractor itself with its gear, or to 9 per cent. for a trailing tractor, is not greatly increased by conditions under which a wheeled vehicle sinks so deeply that the tractive effort required to haul it may amount to 40 per cent. of its weight. Conditions produced by swamp or sand can be such that no horse or wheeled tractor could haul the load at all, yet they will present no difficulty to the chain-track tractor.

Drawbar Connection.—In vehicles exerting so heavy a drawbar pull as is possible with the chain-track tractors, it is of great importance that the drawbar connection should be placed as low as practicable without unduly reducing the ground clearance. The couple formed by the drawbar pull at the height of the drawbar, and the ground resistance, acts on the frame of the tractor in the same direction as the couple due to the tractive effort applied at the sprocket teeth; both tend to cause the front of the tractor to rise, and, as will be seen from Table II, pages 144 and 145, the portion of the load carried on the front wheel is usually small. For this reason it is advisable in designing vehicles of short base and heavy drawbar pull that the drawbar shall be placed low. In vehicles intended for soft and marshy ground it is desirable to use wider treads rather than to attempt to obtain very great ground clearance for the drawbar. For this reason many makes are fitted with alternative widths of chain track according to the land on which they are at work.

Leading Features of Tractors.—The horse-power, engine dimensions and speed, tractor speeds forward and reverse, track width, length of the track in contact with the ground, weight on track, weight on steering wheels (if any), load per square inch of track, dimensions of steering wheels, radius of turning circle, pitch of chain, capacity of petrol, water and oil tanks, drawbar pull, and ratio of drawbar pull to weight of tractor are given in Table II.

(*To be continued.*)

Trading with the Enemy Act.—The Controller of the Foreign Trade Department has sent us a copy of a new list (No. 46) of additions to the Statutory List of firms of enemy nationality or enemy association with whom persons in the United Kingdom are forbidden to trade. Copies of this list can be obtained at a trifling cost from the Superintendent of Publications, H.M. Stationery Office, Imperial House, Kingsway, W.C.

Decision in a Patent Case.—A case has just been decided before the H.M. Comptroller-General of the Patent Office which is of great importance and interest to all stevedores and others interested in the loading and discharging of ships. A certain Mr. Nicolo Briata applied for a patent for what he termed a scraper, or trimmer, for moving coal, ore, or the like, but which was really intended to be used in the holds of ships for the purpose of drawing grain towards the buckets of an elevator. The grant of the patent was opposed by Mr. J. S. Atkins, a stevedore of Liverpool, on the ground that the applicant (Briata) had obtained the invention from him (Atkins), and also on the ground that the invention was similar to an earlier patent granted to Mr. Atkins in 1915. The Comptroller, in giving his decision, said: "It is, I think, undisputed that the opponent (Atkins) was the first person to describe and claim in his patent, a form of plough with a canted blade which could be adjusted. All that the applicant (Briata) has done would appear to be to take a construction invented by Atkins and adapt to it an ordinary form of adjustability. The step is one which would hardly seem to need any special inventive effort by Briata. Any competent mechanician could suggest a form of adjustability when once the constructions shown in Atkins' patent were disclosed to him. The question, therefore, is—was this alleged invention by Briata obtained by Briata from Atkins, and, viewing the matter as a jury would view it, I have come to the conclusion that the narrow invention claimed by Briata, namely the adjustability of the three-armed plough, was obtained by Briata from Atkins' constructions, and upon this ground, and if necessary, upon other general grounds, I refuse to grant a patent to Briata, and I award the opponent, J. S. Atkins, costs, and direct that such sum be paid by N. Briata." The Comptroller-General further stated that in the event of application being made to him, to have this order made a Rule of Court, he would award Atkins a further sum to be paid by Briata. No appeal against the decision having been lodged, the decision is final.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—The output of all qualities of steel has again reached the maximum, and pressure is by no means so great as it has been in the past. The chief call at present is for the higher qualities for aeroplane work, every ounce of the production being rapidly taken up. There is still a shortage in the supplies of foundry and forge pig, but considerable developments are expected, which will relieve the situation. Business generally has settled down, and the effects of the New Year's stoppage are rapidly disappearing. The increase in the cost of raw material and production generally has been again recognised by the authorities in an advance in the maximum prices of high-speed steel, fixed two years ago. From the first of the month, 14 per cent. tungsten is 3*s.* 8*d.* per pound, and 18 per cent. tungsten 4*s.* 5*d.* per pound. The price of tungsten has been raised by 8½*d.* per pound. Makers of garden and field tools are finding a rapidly increasing demand with the advance of the season. With so many departments devoted to war work, manufacturers are already finding a difficulty in coping with orders, and a promised scarcity is more than probable. The increase in the cultivation of home gardens, the accession of thousands of new allotment holders, is causing an immense demand for spades, forks, rakes and hoes, whereas the facilities for production are strictly limited. Heavy inquiries are out for roller tube expanders, sawyers' wedges, hack knives and rivet drivers. All classes of twist drills are also in continual request. A new industry is being established in Sheffield in the manufacture of aeroplane engines. Important works have been purchased in the outskirts of the city, new shops have been added, and when in full swing it is estimated they will find employment for about 1,500 people. The plant we understand will be self-contained, and the engine parts produced entirely on the spot from the raw material. The business was purchased by Charron, Limited, the Paris motor-car builders, but will now be run as a British concern, with British capital.

South Yorkshire Coal Trade.—No marked alteration is to be noted in the condition of the coal market this week. Steam hards are firmly held. Home consumers are taking maximum quantities, and with the limited shipping business, there remains little on the open market. Cobbles, nuts and slacks are easily absorbed. A fair supply was on offer this week of cobbles and slacks, but nuts are very scarce and commanding top prices. The scarcity of wagons is still adding to the difficulty of obtaining supplies. Gas coals are in strong demand, all the available tonnage going inland on contract account. Household sorts continue in brisk request, though the pressure is hardly so severe as last week. Cokes continue a strong market, and controlled prices generally rule. Quotations at the pit are as follow:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; best large nuts, 18*s.* 8*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* to 18*s.*; best slacks, 14*s.* to 14*s.* 6*d.*; seconds, 13*s.* to 13*s.* 6*d.*; smalls 9*s.* to 10*s.* per ton at the pit.

The Iron and Steel Institute.—The annual and autumn meetings of the Institute will be held at the Institution of Civil Engineers, Great George-street, Westminster, S.W. 1, on the following dates:—Annual meeting: Thursday and Friday, May 2 and 3. Autumn meeting: Thursday and Friday, September 12 and 13.

Rosin and Rosin Oil.—The Minister of Munitions has issued an Order dealing with the trade in rosin and rosin oil. All applications in connection therewith should be addressed to the Controller, Non-ferrous Materials Supply, M.S.–L., Ministry of Munitions, Northumberland-avenue, London, W.C. 2.

The late Mr. Lawrence F. Gjers.—We regret to have to announce the death, in his sixtieth year, at his residence in Carlton-in-Cleveland, last Monday, of Mr. Lawrence F. Gjers, the well-known Tees-side ironmaster. Mr. L. F. Gjers was the son of the late Mr. John Gjers, the founder of the Ayresome Ironworks, of Messrs. Gjers Mills, Middlesbrough, and inventor of the soaking-pits. He controlled the works for a large number of years after the death of his father; in fact, the whole of his activities were centred at the works and in the district occupied by his men and their families, towards whom he always showed a most lively practical interest. His numerous acts of kindness will long be remembered. Mr. L. F. Gjers was a member of the Iron and Steel Institute since 1882; he read several papers before that Institute on the equalisation of varying temperatures of hot blast. He was also a member of the North Riding Military Service Appeals Tribunal, a Unionist in politics and a Justice of the Peace. At the meeting on Monday at the Middlesbrough Education Authority, the chairman (Alderman J. F. Wilson) referred to the death of Mr. Gjers, whom he described as a man with a warm heart, and with great and many interests, and who was most kindly disposed towards people, especially the poorer classes. Alderman John Hedley, M.D., moved a vote of condolence with the widow and family, and said the late Mr. Gjers was an excellent citizen and a man of fine character. Mr. T. B. Davies, of the Dockers' Union, who seconded, alluded to the good relations which had always existed between Mr. Gjers and his workpeople. Mr. Gjers leaves a widow and a grown-up family. A few months ago, his second son, Captain L. Gjers, was reported missing, and has not since been heard of.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Work goes briskly on in the steel-making industry, with the production of war material the principal feature. The most pressing demands of Government embrace light sheets, shell bars, and shipbuilding parts and sections, and the urgency with which these are required necessitates the maintaining of output at the maximum level. Every rolling mill is consequently employed in the endeavour to meet the claims of Government, and therefore only a fractional part of the output is available for the purposes of export. All over, the demands for steel of every description are incessant. During the week the outlook on industrial affairs has brightened considerably and the expectation is that all will yet go well and that complete support will be given to Government in the present national crisis. No change falls to be recorded in prices, which still remain at top level for home trade, and where export business can be dealt with firm rates are in operation.

Malleable Iron Trade.—The all round pressure for delivery in the malleable iron works continues, and makers are hard pressed in their efforts to carry through all the orders on their books. Bars of every size are being turned out in enormous numbers to supply the demands of the home consumers engaged on war work for, as things are, little consideration can be given to export, which is strictly limited to small dealings with the Allied Governments. Meantime, local rates have not been affected by the rise of about 20*s.* per ton in the price of English "Crown" bars, and the current quotation for the home trade is 15*l.* 15*s.* per ton, and for export 16*l.* to 16*l.* 5*s.*, while for near delivery even 16*l.* 10*s.* has been realised.

Scotch Pig-Iron Trade.—In the pig-iron trade little change has taken place during the week in the condition of affairs, the demand for all grades is still very brisk, and every effort is being made to deliver the requisite quantity to the several works employed on Government contracts. The scarcity of most brands is felt and, so far as hematite is concerned, the entire output is now reserved exclusively for war work. Export is dull, while for the home trade nothing is available except what is required either directly or indirectly for home work. Rates for export are strong, with every probability of a further advance in the near future.

Transport of Iron Ore.—During the past three and a half years the transport of iron ore to the Clyde has been a matter of supreme importance, and some interesting facts relative to the improvement in the discharge of the cargoes shipped to Glasgow were made public at a conference held in the Christian Institute, Bothwell-street, on Friday last, under the auspices of the Ministry of Munitions, West of Scotland area. Mr. Burton Chadwick, Director of Munitions, Overseas Transport, was introduced to the meeting by Mr. Fred. Lobnitz, Director of Munitions in Scotland, and gave a very clear and succinct explanation of the objects for which the meeting had been called. The great desire of the Overseas Transport, he said, was to speed up so far as possible the transport from overseas of all war material, especially minerals, and to have this so expeditiously discharged that no delay might be occasioned in the return of the vessels. Saving of time was the main point, and Mr. Chadwick expressed his admiration for the manner in which this had been effected in Glasgow. Figures were quoted which showed that during 1917 the saving in the discharge of vessels of iron ore had amounted to about 1,350 ship's days, equivalent to something like from 55 to 60 extra ship's voyages. Various other speakers addressed the meeting, and in the discussion which followed points were suggested in connection with labour, mechanical appliances, works' organisation, railway facilities, &c., which might materially assist further developments alike in Glasgow and at ports on the Ayrshire seaboard.

PERSONAL.—Messrs. J. Hopkinson and Co., Limited, Britannia Works, Huddersfield, state that their present London offices have been taken over by the Government, and their address is now Hastings House, Norfolk-street, Strand, London, W.C. 2; telephone number, 3460 Central; telegrams, "Valvestem," 'phone, London.

A NEW COPPER AREA.—In a paper read before the Royal Society of Arts on Wednesday, the 6th inst., Mr. Wm. Frecheville, Professor of Mining at the Royal School of Mines, said that in the northern part of Canada there is already evidence of the existence of copper over a large area. Specimens or nuggets of native copper were first obtained from the Esquimaux, who used the metal for their implements, and the occurrence was subsequently confirmed by the few travellers who have been in that region; and it is interesting and significant to note that the specimens of rock which have been brought from these, point to the occurrence being geologically similar to that of the highly-productive and profitable copper mines of the Lake Superior district of the United States. The new copper district referred to is situated east of Great Bear Lake and along the course of the Copper Mine River, which runs north from about latitude 65 deg. into Coronation Gulf in the Arctic Ocean. Evidences of the occurrences of copper are also reported as far east as Bathurst Inlet, and on Victoria Island. There appears to be no doubt as to the above facts, and consequently the present position may be summed up by saying that there may be a great copper field somewhere in that region awaiting development, and that the locality is worthy of being carefully examined and prospected both from a Canadian and from an Imperial point of view.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Home transactions in Cleveland pig-iron under the allocation system are on an extensive scale. Complaints are still heard of difficulties experienced with regard to deliveries. The truck shortage is still a serious obstacle to regular and adequate supplies being sent forward, but traders are adapting themselves to the situation, and by the utilisation of lighters for distribution on the North-East Coast there has been no inconsiderable easing of the pressure upon railway transport, and the fact should not be lost sight of that the pressure on transit is quite abnormal, for at one time all the iron from this district for Scotland and Wales was despatched per steamer, whereas now it is sent per rail. Under the conditions prevailing deliveries must be considered on quite a satisfactory scale. Furnaces are stated to be working much better than they have been with the result that more of the better qualities of iron are being manufactured. Foreign trade is very quiet. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry, and No. 4 forge, all stand at 95*s.*, and No. 1 is 99*s.*; and for shipment to France and Italy, No. 3 and the lower qualities are all quoted 114*s.*, and No. 1 119*s.*

Hematite Iron.—There appears to be very little relief to the stringency which has characterised the East Coast hematite branch of trade for some time past, but improvement should follow the increasing utilisation of native ores for production of basic steel. There is now hardly any hematite available for export, but careful distribution continues to assure deliveries to home customers on a scale sufficient to meet minimum needs. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, and 147*s.* 6*d.* for export to France and Italy.

Foreign Ore.—The sanction of a half-crown advance in price of foreign ore has resulted in merchants putting a little more business through, and deliveries show some improvement.

Coke.—Large, all round, demand for coke is met by ample supply, and business is on an extensive scale. Local consumption is very heavy. For home use foundry kinds are 38*s.*, medium blast furnace sort 33*s.* at the ovens, and low phosphorus quality 35*s.* 6*d.* at the ovens; whilst for export to neutrals foundry description is 45*s.* f.o.b., and gashouse product 38*s.* to 40*s.* f.o.b.

Manufactured Iron and Steel.—The various branches of the finished iron and steel industries present few new features of moment. Producers are kept so busily engaged endeavouring to cope with Government requirements, and shipyard needs, that transaction of ordinary commercial business is almost impossible. Quotations are fully maintained at the fixed maximums, the following being among the principal market rates to home customers:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 19*l.* 10*s.*; packing iron and steel (parallel), 13*l.* 10*s.*; packing iron and steel (tapered), 15*l.* 15*s.*; steel bars (no test), 15*l.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

Iron and Steel Shipments.—The customs returns of the shipments of pig iron, manufactured iron and steel, from the port of Middlesbrough for the month of January show a fairly substantial improvement as compared with the statistics for the two previous months. The December aggregate is given at 36,950 tons, and the November total at 39,946 tons, whereas in January 51,718 tons of material were cleared. The October loadings, however, reached 60,777 tons. The pig-iron despatched last month amounted to 31,022 tons, as compared with 27,270 tons in December, 23,638 tons in November, and 29,412 tons in October. January shipments of manufactured iron and steel reached 20,696 tons, as against 9,680 tons in December, 16,308 tons in November, and 31,365 tons in October last.

IRON AND STEEL.—A notice, dated the 1st inst., altering maximum price of marked bars, and limiting extras chargeable on sales of steel in shell discard quality, has been issued, and all applications concerning this notice should be made to the Controller of Iron and Steel Production (Room 382), Ministry of Munitions of War, Whitehall-place, S.W. 1.

ROYAL INSTITUTION.—A general meeting of the members of the Royal Institution was held on the 4th inst., Sir James Crichton-Browne, J.P., F.R.S., treasurer, in the chair. J. Turner MacGregor-Morris and Professor Paule Popovic were elected members. The secretary announced the decease of Sir John Wolfe Barry, member of the Royal Institution, and a resolution of condolence with the relatives was passed. The managers reported that Dr. Mond, under the Conveyance and Deed of Trust of the Davy Faraday Research Laboratory of the Royal Institution, covenanted to pay to the Royal Institution before the year 1926, the sum of 62,000*l.* as endowment fund. The trustees have in the most generous way anticipated the obligation by eight years, and have transferred the sum of 66,500*l.* in 5 per cent. War Stock to the trustees—nominated by the managers—of the Davy Faraday Research Laboratory Endowment Fund. This will add materially to the income available for the purpose of promoting and maintaining the efficiency of the Davy Faraday Research Laboratory, in the advancement of original research in chemical and physical science.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—Interest in the local markets this week has centred chiefly on the Coal Controller's revised directions as to the sale of coal, both for inland consumption and for export. General disappointment is expressed at the failure of the Controller to increase the price of coal for export. South Wales collieries are still suffering seriously from the incidence of the September wage advance to the miners, and the insufficiency of the 2*s.* 6*d.* per ton increase in the price of coal which was given ostensibly to meet the cost of the miners' war wage. It is felt that the matter cannot be allowed to rest where it is, and that pressure will have to be brought to bear on the Controller to revise his price again. While the scheduled prices have been increased by the addition of the October 2*s.* 6*d.* per ton increase, France and Italy will continue to be exempted. In some cases it is reported that companies are now making arrangements for the closing down of pits for the period of the war. The Coal Controller has power to insist on the working of collieries which he considers necessary in the national interest, but it is pointed out that unremunerativeness cannot be borne indefinitely by the colliery companies; unless action is taken to prevent them, they will in all likelihood shut down some of their pits in the course of the next few weeks. Bituminous coals continue in good demand, but the glut of export coals has been accentuated during the past few days by a falling-off in the French demand for nuts. The refusal to grant licences continues to react unfavourably on the production of foundry coke.

Newport.—There is no new development to report for Newport coals. Collieries producing house and other bituminous coals are fairly busy, but there is no pressure in any other direction. Producers for the inland market could do very well with a great many more wagons for the purposes of inland trade. Complaints of delays in the returns of empties from the south-western counties are chronic, but it is a matter of difficulty to fix the responsibility for these delays, and they consequently remain unremedied.

The Supply of Pitwood.—Pitwood is in fair supply for the South Wales collieries just now. It is understood that the home-grown price has been raised from February 1 to 65*s.* per ton at the pit, as compared with the import price of 65*s.* per ton for foreign wood ex-ship.

Short Time at the Collieries.—A conference was held at Cardiff to-day at the request of the Controller of Coal Mines to consider the question of the transfer of miners from collieries working short time to collieries producing house, gas and coking coals, of which descriptions there is a shortage at the present time. The attendance at the conference included representatives of the Coal Controller, Mr. Finlay A. Gibson and the Right Hon. T. Richards, M.P. (representing the Coalowners' Association and the South Wales Miners' Federation respectively). From information which Mr. Gibson had obtained it was ascertained that employment could be found for a number of miners subject to proper arrangements being made as to housing accommodation and railway facilities. As the result of a general discussion it is understood that steps will be immediately taken with a view to endeavouring to place men in collieries where they can be employed with advantage.

SHIPYARD EXTENSIONS IN BELFAST.—Speaking at a meeting of the Belfast Harbour Board last Tuesday, Mr. Robert Thompson, M.P., stated that the board had recently concluded an arrangement for the letting for shipbuilding purposes of 73 acres of land on the east side of the Musgrave Channel to Messrs. Harland and Wolff. This was in addition to 40 acres let to them on the west side of the channel, and a further letting of 20 acres to Messrs. Workman and Clark.

THE AMERICAN SOCIETY OF CIVIL ENGINEERS.—According to information received from New York, Professor A. N. Talbot, of the University of Illinois, has been elected president of the American Society of Civil Engineers. This society is the oldest and most influential of the four national engineering societies. It has a membership of 8,225, an annual budget of 150,000 dols., and assets of 600,000 dols. It was organised in 1852. Its headquarters are in the United Engineering Building, 39th-street, New York. Professor Talbot's election to the presidency is an exceptional honour for men in academic life. In the history of the society only two other college men have been presidents, these being Professor Swain of Massachusetts Institute of Technology, and Professor Marks of Leland Stanford. Professor Talbot is a graduate of the University of Illinois, class of 1881, and has been a member of the faculty of that institution since 1884. Since 1890 he has been head of the department of Municipal and Sanitary Engineering and in charge of theoretical and applied mechanics; he has directed important investigational work in engineering materials, reinforced concrete, railroad track, hydraulics, water works, and sewerage. As a consulting engineer, Professor Talbot has been connected with many large enterprises, such as the Galveston Causeway, the Chicago City Hall, and numerous water works and sewage purification problems. Professor Talbot is a past president of the Society for the Promotion of Engineering Education and a past-president of the American Society for Testing Materials. The University of Pennsylvania has conferred upon him the honorary degree of Doctor of Science and the University of Michigan the honorary degree of Doctor of Engineering. He is the author of numerous books and publications among which "The Railway Transition Spiral" has been extensively used as a text-book.

THE VICTORIA CONCRETE MIXER.

CONSTRUCTED BY MESSRS. STOTHERT AND PITT, LIMITED, ENGINEERS, BATH.

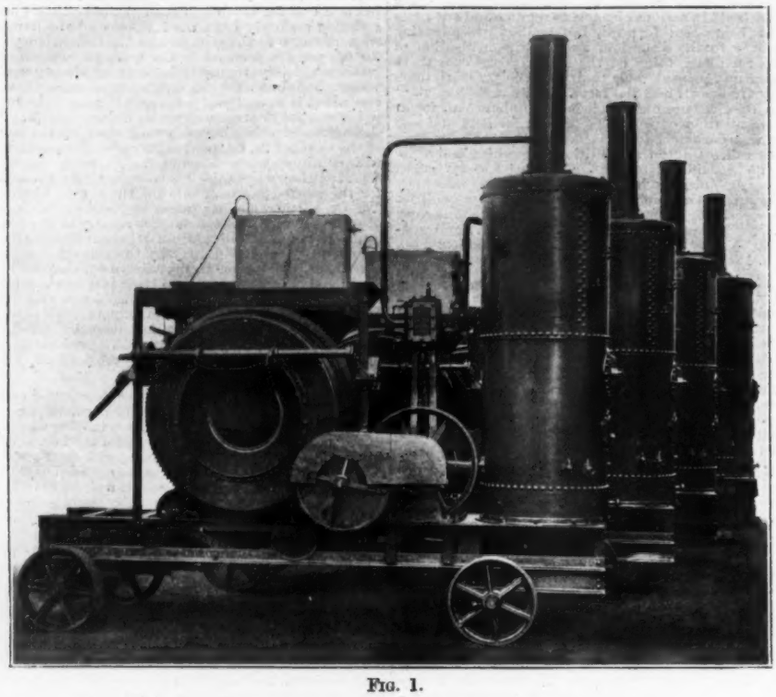
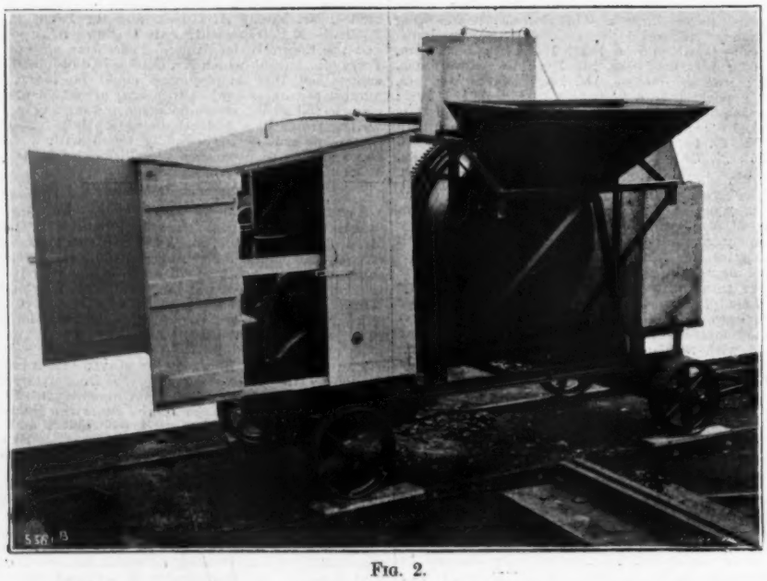


Fig. 1.



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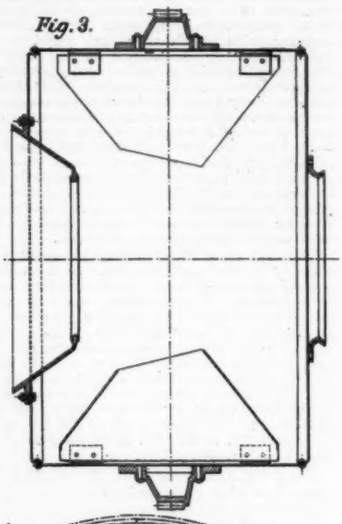

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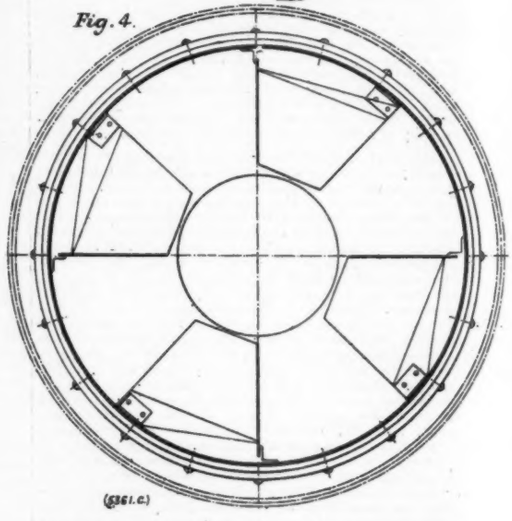

(3361.c)

The Victoria mixer has been manufactured in this country for a number of years by Messrs. Stothert and Pitt, Limited, of Bath, and no doubt the main features of the machine are familiar to a large number of our readers. In recent years, however, certain modifications and improvements have from time to time suggested themselves, and the most recent type is shown in the illustrations, Figs. 1 to 4, on this page.

The mixer has a cylindrical drum and is of the batch type, which is claimed by the makers to be more reliable than the continuous mixer. The materials are accurately measured for each charge, so that no uncertainty exists as to the mixed concrete containing the correct proportions. During the period of mixing, the next charge can be assembled in its correct proportions in the hopper or charging bin.

The interior of the drum calls for special attention, as a thorough mixture and rapid discharge depend upon the arrangement of the blades, and the provision for getting the concrete out of the drum quickly. The improved design comprises four large hopper-shaped blades fixed to the interior of the drum. It will be noted that the sides of the blades do not extend to the circumference of the drum, but leave a space which has been found by experience to increase the circulation of the materials. When the mixer is charged, the drum is filled up to the level of the inlet and outlet orifices, and during the revolution of the drum the whole of the batch is kept in a state of constant circulation, the greater part of the material being carried round by the blades to a certain point, when it is poured back towards the bottom of the drum.

At the discharge side the drum is made concave. The object of this is to eliminate any splashing, which is a tendency of all non-tilting mixers of this type, and it may be pointed out that it is a comparatively easy matter to increase the speed of discharge at the expense of splashing. In addition to this, the discharge chute can be designed to extend well beyond the centre line of the drum, so that it catches every particle of material coming from the blades. When the batch is completely mixed, the discharge chute is inserted into the drum and the material carried round by the blades, instead of falling back into the drum, now falls on to the end of the discharge chute and into a contractor's tip wagon or other receptacle placed alongside. The angle of chute is much steeper than is possible with a flat discharge drum end, and recent experiments have shown that the speed of discharge has been greatly increased and splashing avoided.

The drum construction throws the load on to the centre line of the mixer, where the driving ring is fixed. The drum is supported on four rollers, two on each side of the driving ring, and to ensure proper alignment the ring with the two roller tracks is made in one casting, and any slight twist of the drum shell does not affect the alignment of the mixer, with the result that smooth running is obtained.

We illustrate two views of a number of ¾ cub. yard Victoria mixers now being completed for the Government. Each plant consists of the mixer fitted with batch-charging hopper and water tank mounted on road-wheel truck with swivelling fore-carriage, in one case (Fig.1) driven by steam engine and boiler, and in the other by paraffin engine (Fig. 2).

It will be noted from the view, Fig. 2, that the paraffin engine is mounted on an extension of the mixer underframe, and with the cooling tank and other accessories placed on the other end of the frame, forms a complete unit. The Victoria mixer is made in various sizes, and can be fitted either with batch hopper as shown or elevator.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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TELEPHONE NUMBERS—3603 and 8508 GERRARD.

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With a Two-Page Plate of a 10,000-*Kw. STEAM TURBINE AND CONDENSER FOR THE PEDRO MENDOZA POWER STATION, BUENOS AIRES.*

NOTICES OF MEETINGS.

THE PHYSICAL SOCIETY OF LONDON.—Friday, February 8, at 5 p.m., at the Imperial College of Science, Imperial Institute Road, South Kensington, S.W. After the election of Officers and Council, presentation of reports, &c., the following papers will be read:—"A Recording Thermometer," by Professor C. V. Boys, F.R.S. "The Primary Monochromatic Aberrations of a Centred Optical System," by Mr. S. D. Chalmers, M.A.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, February 9, at 2 p.m., in the Wood Memorial Hall, Newcastle-upon-Tyne. The following papers will be open for discussion:—"A Fresh Aspect of Intensive Mining Thin Seams," by Mr. George Gibb. "The Flow of Water in Syphons," by Mr. Mark Halliday, B.Sc. "Notes on the Uniflow Steam Engine," by Mr. G. G. T. Poole. The following papers will be read or taken as read:—"Memoir of John George Weeks," by Mr. R. J. Weeks. "A System of Storing and Filling Small Coal, with remarks upon the Prevention of Spontaneous Heating in Coal Heaps," by Mr. John Morison. "The Strength of Pit Props," by Mr. Fred. L. Booth.

THE MINING INSTITUTE OF SCOTLAND.—Saturday, February 9, at 2.30 p.m., in the Heriot Watt College, Chambers Street, Edinburgh. Office-bearers for 1918-19 will be nominated. Mr. George Gibb's paper, on "A Fresh Aspect of Intensive Mining in Thin Seams," will be discussed. Mr. David M. Mowat's paper, on "Capital Charges Considered along with Current Expenses," will be discussed. A paper will be read by Mr. Henry Rowan, on "Stripping and Re-Lining a Shaft at Cowdenbeath, Fife." A paper will be read by Mr. Robert W. Dron, on "The Occurrence of Coking Coal in Scotland."

THE KEIGHLEY ASSOCIATION OF ENGINEERS.—Saturday, February 9, at the Assembly Room of the Cycling Club. A paper will be read by Mr. Thos. R. Shaw (Churchill Machine Tool Company, Limited), on "British Design Cylindrical Grinding Machine: External and Internal." Chair to be taken at 6.30 p.m. by Mr. Arthur Sellers.

THE SOCIETY OF ENGINEERS.—Monday, February 11, at 5.30 p.m., in the apartments of the Geological Society, Burlington House, Piccadilly, W. Mr. W. B. Esson, the President for 1918, will deliver his Presidential Address.

THE ROYAL SOCIETY OF ARTS.—Wednesday, February 13, at 4.30 p.m. "The Relations between Capital and Labour—Reasonable Hours, Co-partnership and Efficiency," by Lord Leverhulme. Thursday, February 14, at 4.30 p.m. Indian Section.—"The Hide Trade and Tanning Industry of India," by Sir Henry Ledgard, late President, Upper Indian Chamber of Commerce. The Right Hon. Lord Islington, P.C., G.C.M.G., D.S.O., Under-Secretary of State for India, will preside.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, February 13, at 8 p.m., at the Royal Society of Arts, John Street, Adelphi, W.C. 2, when Mr. Ernest A. Savage will read a paper, entitled "The Utilisation of the Data of the Automobile Industry through Bureaux of Information."

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, February 13, at 8 p.m., at St. Bride's Institute, Bride Lane, Fleet Street, E.C. A paper will be read by Mr. W. T. Stevenson, on "The Place of Economics in Transport and Engineering." The President in the chair.

THE OPTICAL SOCIETY.—Thursday, February 14, at 8 p.m., at the Imperial College of Science and Technology. Annual and extraordinary meeting, followed by ordinary meeting, when a paper, on "Reflecting Prisms," by Naval Instructor T. Y. Baker, will be read and discussed.

THE FARADAY SOCIETY.—Thursday, February 14, at 7 p.m., at the Municipal School of Technology, Whitworth Street, Manchester. General discussion on "Electric Furnaces." Professor C. A. Edwards, D.Sc., will be in the chair. The discussion will be preceded by the reading of the following papers:—"Application of Electric Furnace Methods to Industrial Processes," by Mr. H. Etchells. "Electric Furnaces for Steel Refining," by Mr. J. Bibby. "Electric Furnace Control," by Mr. A. P. M. Fleming and Mr. F. E. Hill. "A High-Temperature Electric Resistance Furnace," by Mr. E. A. Coad-Pryor and Mr. W. Rosenhain, F.R.S. A contribution by Mr. Donald F. Campbell.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, February 15, at 6 p.m., at the Institution of Civil Engineers, Great George Street, Westminster. The Annual Report of the Council will be presented. Papers to be discussed: "Traction on Bad Roads or Land," by Mr. L. A. Legros, Member, of London, and "Utility of Motor Tractors for Tillage Purposes," by Mr. Arthur Amos, of Cambridge.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, February 15, at 5.30 p.m. A discourse will be delivered by Professor E. H. Starling, M.D., D.Sc., F.R.S. The subject is "The Mechanism of the Heart." Afternoon lectures next week at 3 p.m. Tuesday, February 12. Professor Arthur Keith, M.D., F.R.S., Fullerian Professor of Physiology, Royal Institution, on "The Problems of British Anthropology" (Lecture II). Thursday, February 14. Edmund Gosse, C.B., LL.D., on "Three French Moralists and their Influence on the War—La Rochefoucauld" (Lecture I). Saturday, February 16. Professor Sir J. J. Thomson, O.M., Pres.R.S., Professor of Natural Philosophy, Royal Institution, on "Problems in Atomic Structure" (Lecture I).

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16, 1917. The change will not apply to unexpired subscriptions.

ENGINEERING.

FRIDAY, FEBRUARY 8, 1918.

THE SINS OF THE CAPITALIST.

LABOUR is very acutely conscious of the sins of the capitalist. In Russia its representatives lately announced its intention of waging war with the bourgeoisie of Germany, France and England simultaneously to insure their extinction. In this country the demand for the conscription of capital is becoming more and more insistent, and we are told that labour looks forward to assuming the reins of government after the next election to enforce the demand. In three of the monthly reviews—the *Nineteenth Century*, the *Fortnightly* and the *Contemporary*—there are articles dealing with the conscription of capital in one way or another. In the latter journal the Right Hon. Arthur Henderson, M.P., lays down the programme of the Labour Party as regards, *inter alia*, the reconstruction of society after the war. He says: "Our programme of reconstruction starts from the assumption that the individualist system of capitalist production has broken down. It was discredited by its results before the war; it was superseded when war came, because it was impossible to adapt it to national needs in time of war . . . To attempt to restore it would be madness . . . We set our faces resolutely against any proposal which will have the effect of re-establishing this system of private ownership and competitive administration of land and capital. . . . Neither State capitalism nor State Socialism is our objective, but rather industrial democracy. We shall therefore resist every proposal to hand back to private hands the great industries and services which have come under the control of the community during the war. Not only large undertakings like the railways, shipping and the mines, but many important processes and enterprises, such as the purchase and distribution of raw materials and of staple articles of food have been wholly or in part nationalised, and the Labour Party, far from wishing to relax this form of control, wish to see it extended and strengthened." When a political party want to prolong the present system of management of our great industries rather than revert to that before the war, it is clear that the sins of the capitalist must have become an obsession to them. They are so impressed with the shortcomings and defects of the previous system, that they are prepared to accept gigantic risks in the search for a remedy.

We have, however, grown accustomed to the visions of Socialists and of industrial democrats, and have got into the way of dismissing them as the theories of men who are unfamiliar with manufacture and commerce, and hence are quite blind to the difficulties that would have to be faced, or rather endured, if their scheme could be put into operation. But when, quite recently, it was announced that Mr. W. L. Hitchens, chairman of Messrs. Cammell, Laird and Co., Limited, had stated in his Watt Anniversary Lecture, that all profits ought to be limited to a fixed standard of interest, and that a substantial proportion of any excess profits over that standard should accrue to the State, capital felt that it had indeed been wounded in the house of its friends. Since Mr. Hitchens is the head of a great shipbuilding and engineering firm, and was recalling the triumphs of the father of steam engineering before an audience comprising many engineers, it was fair to presume that he had the profits of engineers in the forefront of his mind at the time he spoke. Where are these profits that stand in such need of pruning? He would have been a very astute investor who could have distributed 100,000*l.* during the early years of the present century in the purchase of engineering shares to bring in an average of 6 per cent. Of course, there are a few exceptional cases of 12 per cent., 15 per cent. and 20 per cent., but even in such cases special conditions fully explain the excess over the prevailing low average. Such instances are a very small proportion of the whole, while on the other hand there are numerous large firms who have defaulted in their preference interest, and even on their debentures. We very much doubt whether the engineering limited liability companies pay, on an average, as much as 6 per cent. on their aggregate capitals, including preference and debenture stocks.

Wherein, then, have they sinned against the community or against labour? Even if they had abandoned all profit the return to labour would not have been increased very perceptibly, save in exceptional cases, while the community would certainly have been no better off. Nevertheless the socialists denounce the enormous profits of capitalists, and they point to the sums which are

assessed to death duties in proof of their statements. It is undoubtedly true that many large engineering businesses have been built up out of profits over a series of years. It needs only a moment's consideration, however, to show that money grows very rapidly when invested at compound interest in a prosperous concern. At 8 per cent. it doubles every nine years, so that in thirty-six years each 1*l.* becomes 16*l.* It was in this way that in the last century many small jobbing businesses became large manufacturing concerns. The owners worked hard and lived sparely. The bulk of their profits were expended in plant and on extensions, and when they died they left large fortunes. Would the world, or labour, have been better off, if from the first they had paid away their profit in increased wages or taxes. Instead of a huge factory worth, say, 200,000*l.* and employing 1,800 men, there would have been the original smithy or foundry, and nothing more. The extra wages would, quite naturally, have been consumed in extra food and comforts, and while there would have been no accumulations to testify to the sins of the capitalist, there would equally have been no plant to afford work to an increasing population and to provide exports to pay for imported food.

One of the main causes of our falling behind Germany in many branches of manufactures has been a deficiency—not an excess—of profits. For example, our iron industry has been nearly stationary for some years, while that of Germany has advanced and passed us by a long way. This country is equally well able as Germany to turn out iron of good quality and reasonable price. But the financial results have not of late years been sufficiently promising to attract capital. Works and plant have not been extended, new processes have not been adopted to the extent they should have been, and the war found us quite unable to supply our own needs, not to mention those of our Allies. It would be easy to multiply instances, but surely it is clear that unless the accumulation of capital is always going on it is impossible to extend plant *pari passu* with the increase of population and with the steady rise in the standard of living. It must be remembered that a man must be a capitalist before he can engage in semi-speculative enterprises, or indeed before he can make any serious accumulations. The man of small means has so many needs that cry out to be satisfied that he must have great resolution and pluck to turn a deaf ear to them and save continuously. And when he has become possessed of a few hundred pounds he would be ill-advised to run the risks of an industrial investment. An extra 2 per cent. will bring in very little, but the loss of half the capital may make the difference between comfort and poverty in the last years of his life. Speaking generally it is the capitalist classes who save, and who are the readiest to adventure their accumulations in enterprises which furnish employment for labour.

Mr. Hitchens' views about the gains of capital, which created so much surprise, were published first in a telegraphic summary. When the full text became available it was seen that although his words had been correctly reported, yet he had added others which modified their application very considerably. Some of his Scotch audience must surely have been reminded of the Highland minister who was instructed by the Synod to preach on the evils of dram-drinking. He loyally warned his congregation against the physical, social and moral disasters caused by alcoholic spirits. But, descending from the general to the particular, he then explained that it was not whisky *per se* that was noxious, but only the excessive use of it, and he went on to give instances of the times at which drams could be taken not only with safety but also with advantage. These began at breakfast, and recurred at gradually diminishing intervals during the day until the final dram, "or may be twa drams," as a night cap. The congregation dispersed feeling that they were not really serious sinners, and in like fashion engineer capitalists may find matter for consolation, if not satisfaction, in some of the saving clauses in Mr. Hitchens' lecture. He said: "It is not suggested that all opportunities for individual gain ought to be eliminated, only that the good of the individual should come after—not before—the good of the community where the two conflict. . . . It would be necessary to provide that adequate allowances be made for depreciation and for reserves to secure the stability and development of business. The wholly inadequate provision for depreciation allowed under the income-tax regulations to-day has, I believe, done serious injury to the industries of this country. It has encouraged over-capitalisation; it has hampered the scrapping of old and the substitution of modern machinery; it has given us a retrograde in place of a progressive standard."

If engineering businesses be administered in this liberal spirit in the future very few will need to fear being mulcted in excess profits for a long period. The trouble with most of them is that they have paid far too much away in dividends and income-tax, and that there are long arrears due to depreciation and obsolescence which do not appear as liabilities in the balance sheet. In the comparatively few instances in which this is not the case the result is due to a cause of which Mr. Hitchens makes no mention, that is, to individual ability. There are some firms which, in spite of the stress of competition do make large profits, and in most cases these may be traced distinctly to the business or technical ability of one or more of the managers. What has "the principle that no section of society is entitled to an unlimited share of the wealth of the community" to do with such a case? It may apply to the methods of an oil trust, or beef trust, which creates an artificial scarcity, and so secures a greater share of the wealth of the community, but it has no application to the man who creates wealth, and in so doing benefits society. Let us consider it with relation to a farmer who by skill raises 50 per cent. more food per acre than his neighbours, and makes corresponding profits. What possible justification can there be for putting an excess tax upon him? He already pays more in income-tax because of his skill and industry, while on principles of justice he really ought to have a reduction. Surely Mr. Hitchens must, in writing the sentence, have had in his mind the case of a country surrounded by a tariff wall. Then it becomes intelligible, since if the community creates artificial conditions favouring the manufacturer it has the right to a share of the results. But that is not the case here. The successful business man makes his large profit because he works more efficiently than his competitors, and he is always forcing them to revise their methods and follow his lead, or else to face disaster. In the early part of his lecture Mr. Hitchens struck a high ethical note; he said a man "can only serve himself by serving the community, and this is surely the only sound foundation on which industry can rest." Quite so; this is exactly what the successful man does, and there is high ethical authority in justification of the saying—"For he that hath to him shall be given, and he that hath not from him shall be taken, even that which he hath."

Large profits will be difficult to make in the immediate future because labour is claiming—and rightly claiming—increased pay. Experience during the war has shown that our output in the past has been unduly expensive, and that production can be very greatly increased by the exercise of more thought on the part of the management and more energy on the part of the men. Increased wages will tell most seriously against the really efficient firms, for it is always difficult to improve a machine that is already fairly perfect. But there is hope in the reflection that the brain power to achieve efficiency being existent it can be stimulated to higher achievement. It is partly a matter of habit. The old-fashioned firms, who were more or less ignorant of the art of manufacture, will have the easier task, although under the best conditions it may be some years before they can secure their position, and some must succumb under the stress of high wages before they can reorganise themselves. In view of this, Mr. Hitchens contends that "the reward of labour must, in the last resort, be determined by the State as representing the community." We have seen much of this action of the State, or rather of the Government, during the past year or two, and that experience does not lead us to put great reliance on it for the future. The State under our party system is a very poor representative of the community, especially when a minority of the population is strongly organised, while the remainder is uncombined and almost inarticulate. The State is very apt to take the line of least resistance at the moment without duly considering the future. It is always much easier to tax capital than labour, and it is also justifiable up to a certain point. But to tax brains, energy and thrift is a ruinous policy, and we think that the glowing ethical picture which Mr. Hitchens painted must have somewhat dazzled his intellectual vision so that he could not clearly discern the effect of his recommendations when studied in the cold light of economics.

POWER STATION ECONOMY.

A few years ago we published an article entitled "The Law of Power Plant Economy," which showed that the coal and water consumption of a complete power plant could be represented by two simple equations. The method is due to Mr. R. H. Parsons, M.Can.Soc.C.E., who illustrated it by giving the actual diagrams and equations representing the efficiency of a large power plant under his management. The diagrams are obtained by plotting the usual station records on squared paper, and from them equations are deduced which not only permit the performance of the station at all loads to be determined, but provide a means of comparing the working of the station with that of other plants irrespective of size and output.

For a description of the method we would refer our readers to the original article, which appeared in our columns on November 13, 1914, but we return to the subject in view of some very interesting figures recently obtained by the analysis of an English power station on the lines advocated in the article. The plant in question is that of the North Metropolitan Electric Power Supply Company, Limited, at Willesden, with an output of about 25,000,000 kw.-hours per annum. Having grown from small beginnings, much of the machinery is far from modern, yet the engineering policy of the company under Mr. Ruthven Murray has always been progressive, and the station contains the first Ljungstrom turbo-generator ever built. This machine was illustrated and described in Engineering of April 12, 1912. The rated capacity of the main generators aggregates 15,000 kw., the machines varying from a 300-kw. Ferranti-Westinghouse direct current set to a 5,000-kw. Ljungstrom turbo-generator. Mr. F. D. Napier, the resident engineer of the station, has analysed the results of the plant by the method we have referred to, and has found that the average performance, taken over a period of several months, can be represented by the following equations:—

$$C = 17{,}000 + 2.17\,K \quad . \quad . \quad . \quad (1)$$

$$W = 12{,}000 + 16.48\,K \quad . \quad . \quad . \quad (2$$

in which

C = Pounds of coal burnt per 8-hour shift.
W = Pounds of water evaporated per 8-hour shift.
K = Kilowatt-hours generated per 8-hour shift.

These two equations show how the coal and water respectively vary with the load on the station, and by solving them simultaneously two more equations can be obtained, which give the relationship between the coal burnt and the water evaporated. The latter equations, which are as follows:—

$$C = 15{,}420 + 0.1317\,W \quad . \quad . \quad . \quad (3)$$

$$W = 7.594\,C - 117{,}106 \quad . \quad . \quad . \quad (4)$$

are really identical, but it is useful to state the alternative forms in order to bring out particular facts.

From equation (1) we see that the total coal burnt may be divided into two parts, firstly, a constant quantity of 17,000 lb. per shift, which is independent of the load and obviously serves to supply the heat lost in radiation and the other constant losses in the station; and, secondly, a quantity of 2.17 lb. for every kilowatt-hour generated. The equation also shows that if the load fell to zero, so that no kilowatt-hours were generated, the station would nevertheless require 17,000 lb. of coal to be burnt per eight-hour shift; in order to keep the plant in a condition for

immediate resumption of supply. Thus the total no-load losses of the station are equivalent to less than 1 ton of coal per hour. This we consider to be remarkably good, and to bear witness to the care taken in the maintenance of the plant.

The no-load losses themselves may also be divided into two parts, namely, the heat losses occurring in the boiler-room, and those due to the loss of steam after it has left the boilers. Equation (3) shows us that the total coal consumed per shift may be looked upon as the sum of a constant quantity of 15,420 lb. plus a quantity of 0.1317 lb. for every pound of water evaporated. Hence, were no steam to be taken from the boilers, they would still need 15,420 lb. of coal per shift to balance the furnace and radiation losses. Of the total no-load coal consumption of 17,000 lb., therefore, 15,420 lb. are required to make good the boiler-room losses, leaving only 1,580 lb. as the equivalent of the condensation and other losses which would occur in the engine-room under no-load conditions. The stand-by losses in the boiler-room are therefore nearly ten times as important as those in the rest of the plant.

Turning now from the consideration of coal consumption to that of steam, we see from equation (2) that the water evaporated amounts to a constant quantity of 12,000 lb. per shift, plus 16.48 lb. per kilowatt-hour generated. At no-load, therefore, 12,000 lb. of steam per shift are leaving the boilers, and are either lost by condensation or leakage, or are employed in driving auxiliary plant. This quantity of "lost steam" is the equivalent of the 1,580 lb. of "lost coal" already found to be incurred by condensation, &c.

Regarding the equations generally, the facts which they embody bear testimony to the efficiency of Mr. Napier's management of the plant, and the consumptions of both coal and water would compare well with those of many stations working under much more favourable conditions. The sources of loss in a power-station are so numerous, and often so far from being obvious, that a constant and rigorous criticism of the operating results is the only way to maintain efficient working. For the criticism to be intelligent it is necessary to know what coal and water consumptions may reasonably be expected under any conditions of load, and to what causes the principal losses are due. This information the equations provide, as they express in the briefest possible form, a logical induction based on the previous records of the station. Further, they enable the engineer to forecast with great accuracy, the consumptions which will be obtained under future conditions of load. From equations (1), (2) and (4) we see at once that the greater the load on the station, the more nearly the following results are obtained, namely, a coal consumption of 2.17 lb. per kilowatt-hour, a steam consumption of 16.48 lb. per kilowatt-hour, and an evaporation of 7.594 lb. of water per pound of coal. These figures represent the limits which would be reached with no change in plant or working conditions other than an increase of load.

There can be no doubt that the method of analysing power-station losses, devised by Mr. Parsons, enables a station engineer to form a far more accurate conception of the efficient working of his plant than he would otherwise obtain. Moreover it permits of the effect on the efficiency of the station of any change of working conditions to be noted within a few hours, and to be brought home graphically to the engineer-in-charge. This is done in the following manner. The equations (1) and (2) being once established for the particular station, each of them is plotted as a straight line on a piece of squared paper. At the end of every shift, the total coal consumption for that shift is plotted against the output, on the first chart, and the total water consumption against the output, on the second chart. If these points are above the respective lines corresponding to the equations of the station, the efficiency of the station on that shift was below the standard, and *vice versa*.

Mr. Napier has adopted a modification of this method, in which the efficiency points are plotted in a consecutive order, and so indicate at a glance whether the station efficiency is improving or not. This is done by subtracting the constant in equation (1) from the coal consumption on the shift, and then dividing the remainder by the output for that shift. For equal efficiency of operation the result will be a constant, whatever the output for the shift, and the efficiency points will thus lie on a straight horizontal line. The water consumption figures can be similarly treated. To make the matter clear by means of an actual example we will assume the coal equation of any given station to be as follows :—

$$C = 20{,}000 + 2.8\,K \quad . \quad . \quad . \quad (5)$$

A chart is prepared in which the ordinates represent pounds of coal per kilowatt-hour, and the abscissæ denote consecutive shifts. On this chart a horizontal line is drawn at a height from the base corresponding to 2.8 lb. of coal per kilowatt-hour. Suppose that at the end of any shift, the returns show that 32,720 kw.hours have been generated and that 112,250 lb. of coal have been burnt, we have then $(112{,}250 - 20{,}000) \div 32{,}720 = 2.819$. The figure 2.819 will be plotted on the chart as the coal consumption figure for that shift, and since it falls above the standard line, it denotes that the economy of the station on that shift was slightly below the standard. By treating the returns of the water consumption in a similar manner, it can be seen whether the fault lay in the boiler-house or in the engine-room. If the water consumption is found to be normal the cause of the coal consumption being slightly higher than the standard must be looked for in the boiler-room.

GRAVITATION AND THE PRINCIPLE OF RELATIVITY.

WHEN we first referred to the principle of relativity in our columns,* the few investigators of the subject were still addressing themselves to a restricted circle of mathematicians. That practically remains so, though the principle is certainly gaining adherents. The general reader who understands the meaning of relativity, does not see much more than a foreign fad in a new version of a so-called generalised principle of relativity which apparently can be expressed only in abstruse formulæ. Motion of a body is unintelligible except in reference to another body. In laboratory experiments we easily find some reference body at rest. But when we consider phenomena outside our earth, which is rotating about its axis while revolving round the sun, itself rushing through space in a universe in which nothing probably is at rest—how are we to find some frame of reference? Those are the problems of relativity. Strict scientists rarely trouble to put new problems in a simple garb, during their early stages, and the attempt is hardly advisable as a rule. But the relativity principle in its new definite aspect has now been with us for a little more than a decade, and our readers will be interested in the very suggestive exposition of the problems in non-mathematical language which Professor A. S. Eddington, F.R.S., of Cambridge, gave last Friday in his Royal Institution discourse on "Gravitation and the Principle of Relativity." He has dealt on other occasions with the mathematical and astronomical features of the subject.†

The introduction of the discourse very happily illustrated what lies at the root of the problem, the strange difference between the world of appearance and the real world. In entering the room, Professor Eddington said, we had to bear an air load of 14 lb. per square inch; at each step we had to tread on ground moving at nearly 20 miles a second round the sun; we were poised on a globe, hanging by our feet outwards into space, and with all that had to face a tremendous wind of æther blowing through us. But we never noticed those phenomena, and there were other extraordinary things of which we were unconscious. The present subject had arisen from the famous Michelson–Morley experiment of 1887. The apparatus was elaborate, the principle of the experiment simple. Which, the lecturer asked, would be more difficult for a swimmer—to swim to a point 50 yards up-stream and back again, or to swim to a point 50 yards across the stream and back again? The net effect of the river current was a delay in both cases. Mathematically the answer was not immediately obvious, but a swimmer would reply that the up-and-down journey took longer. Now we were in a river of æther. Michelson divided a beam of light into two parts; the one part he sent up the stream and back again, the other across an equal distance, as he thought, and back; the two paths could not have been equal, yet it proved to be a dead heat. The whole apparatus was then turned through a right angle, so that the arm which had been along the river, and which must have been a little the longer, was now across it; yet the two beams again arrived at the same moment. In fact, the supposedly rigid arms had contracted when placed in the up-and-down stream position by just the amount necessary to conceal the effect that was looked for.

This straightforward interpretation of the experiment might not have been accepted, were it not for some later theoretical discoveries. Matter was of an electrical nature, the forces of cohesion were electrical forces, and Larmor and Lorentz showed that this property of contraction in the direction of the æther current was inherent—though not proved—in Maxwell's equation. This contraction was a universal property for all kinds of matter as shown by experiment and theory. But it had only been investigated for solids of laboratory dimensions, held together by cohesion; there was no evidence that a body like the earth, whose form was determined by gravitation, would suffer the same contraction, but the contraction was assumed. Supposing now, Professor Eddington continued, that the people in the lecture theatre were carried vertically upward through the æther at 161,000 miles a second—the motion could neither be proved, nor disproved, as all the experiments like the Michelson-Morley experiments had given a null effect. With that speed the contraction would be one-half, and the pointer, 8 ft. in length, which the lecturer held horizontally, would be only 4 ft. long, if turned vertically. Nobody noticed anything of this contraction; for what we saw was only the image on the retina which would likewise contract in the vertical position, and so would the standard yard with which we measured. If everything underwent the same change, it was just as if there had been no change at all. Thus the real world differed from the world of appearance like an object and its distorted mirror image. If our speed through the æther were smaller, the contraction would be smaller; we failed to notice it, not because it was too small, but because it was undetectable from its nature. We imagined natural objects to be placed, not in absolute space, but in a framework of our own contriving, a space which corresponded to appearance. In like manner our time was a time of our own, different from the time we should adopt if our motion through the æther were nil. The space and time framework was something peculiar to us, defined by our motion, and had not the metaphysical property of absoluteness attributed to it. If we were transplanted to the star Arcturus, which moved relatively to us with a velocity of over 200 miles per second, the contraction of objects would be different, and there would be a different space and time framework for Arcturus, and again a different one for any other star.

The exact relation between the appropriate space and time of one star and the space and time of another had first been brought out clearly by Minkowski. Three dimensions were generally recognised, up-and-down, right-and-left, backwards-and-forwards. In Ireland we should still have the same space as in London, but in Ireland the up-and-down no longer corresponded to ours; the directions were inclined. Now assume a fourth dimension of time (imaginary because $\sqrt{-1}$ was involved), at right angles to the other three; there was no room for it in a three-axial model, but we could imagine it. If we went to Ireland the three space-dimensions would appear to have been rotated, as mentioned, but the time would be the same. On Arcturus, however, the time dimension also rotated. What was time to them, would partly be time and partly imaginary space to us. Space-time was the same universally, but the orientation—the resolution

* See ENGINEERING, August 11, 1916, page 132.

† See ENGINEERING, September 27, 1916, pages 297 to 300, British Association discussion.

into space and time separately—depended upon the motion of the individual experiencing it; that was Minkowski's great result, in his own words: "Henceforth Space and Time in themselves vanish to shadows, and only a kind of union of the two preserves an independent existence."

From the original point of view it was very remarkable that the contraction in the Michelson-Morley experiment, and in all the other similar experiments, should just compensate the expected effect of our motion through the æther. It was as if all the forces of nature had entered into a conspiracy to prevent our detecting that motion. It was doubtful, however, whether the force of gravitation, which stood alone in majestic isolation, had joined this conspiracy. Sir Oliver Lodge, believing that it had not, had recently shown that a famous astronomical discordance in the motion of Mercury—the point was referred to again later on—might be due to the motion of the Sun through the æther. But it seemed that stress should be laid, not on this discordance, but rather upon the exact agreement with theory in the cases of Venus and of the Earth. The great advantage of Minkowski's view was that it got rid of all idea of conspiracy. We had been imagining that a space-time world could be cut in some direction so as to separate it into absolute space and time. But why should one direction be more fundamental than any other? We could not cut space in such a way as to find the *real* horizontal and vertical, words which had no meaning except in reference to a particular spot of the earth. So for a particular observer the space-time world fell into four components, up and down, right and left, backwards and forwards, sooner or later; but no observer could say that this division was the only real one. We had materialised space by filling it with an æther, supposed to be at rest in space. Now, however, we denied the existence of any unique framework of that kind; we had no experimental knowledge of such framework, and whatever the nature of the æther, it was devoid of the material properties which could constitute a framework of reference in space. We could best picture the æther perhaps as a four-dimensional fluid filling uniformly Minkowski's space-time *continuum*, not as a material three-dimensional fluid occupying space and time independently.

The position which he had reached, the lecturer proceeded, was known as the Principle of Relativity. Physically the principle was amply confirmed, except as to gravitation; philosophically it was no more than a useful and legitimate point of view. But he passed on to the Generalised Principle of Relativity. If we distinguished between what we perceived and what we inferred, any scientific observation resolved itself into a *coincidence* in space and time. When speaking of measuring a current of 5 milliamperes, the physicist actually observed that the image of his galvanometer wire coincided with that division on a scale. The sum of our experimental knowledge really consisted of a large number of coincidences. A complete history of the progress of a particle would consist of the knowledge of its path and the time at which it occupied each point of the path, and might be summed up by a line in four dimensions, the *world-line* of the particle. Professor Eddington showed his model of such a history of the universe—or part of it—a football bladder, Minkowski's space-time world, on which world-lines were drawn, merely in two dimensions, because drawing in three dimensions presented difficulties, and drawing in four dimensions was impossible. We observed only the coincidence, *i.e.*, the intersections of the lines, and not the place of the intersection, but only the fact of intersection. When the bladder was squeezed, the world-lines were distorted, but the history remained unaltered, for no intersection was destroyed or created. The squeezing constituted a *mathematical transformation*. The laws of nature in their most general form should correctly describe the behaviour of the world-lines in either the undistorted or the distorted model, because it was indifferent which we took as the true representative of the course of nature. That was an important principle; but it did not enable us to determine the laws of nature without making some additional hypothesis. The law of gravitation especially called for attention at that point.

In the undistorted space-time a world-line would run straight—though that statement involved a logical difficulty—unless attracted by other lines near it. A world-line could also be bent, in the model by the pressure of the thumb, a mathematical transformation; but it would still be straight relative to the original material, and still continue to take the shortest path between two points reckoned on the bladder in the unstretched state. The deflection of a world-line by gravitation was of a similar nature, and the earth described a curved orbit round the sun, not because the sun exerted a direct pull, but because the earth tried to find the shortest way through the space-time tangled up by an influence radiating from the sun. This influence might be described as a "force," which made itself felt as a strain of space and time. That might sound a hopeless jargon, Professor Eddington remarked; he was not concerned with metaphysical space, however, but merely with the scaffolding of the measuring apparatus which might go crooked, and which must be crooked, since our conventional space, in which we were at rest, was not the astronomical space through which we were being carried at a great velocity. The earth's centrifugal force was sometimes called an "unreal" force, because it arose merely from a transformation of the framework of reference. But was gravitation more "real"? Both were manifestations of the same underlying condition; the value of gravity, 981.17 cm. per second per second in London, was really made up of the attraction and of the centrifugal force. If gravitation involved nothing more than strain of space-time, then gravitation and centrifugal force should obey the same general law; but Newton's law and the law of centrifugal force were contradictory. If we determined the strains by Newton's law, the results agreed with observation, provided Minkowski's space-time were used. For any transformed space-time, there was no agreement, however; that meant that Newton's law involved something that was not fully represented by strains, and we had to abandon either our assumption, or abandon Newton's law and find a new law of gravitation.

That amended law, the only one possible to meet the requirements apparently, had been found by Einstein. In practical application the old and the new law were indistinguishable; for very strong gravitational fields and velocities far greater than planetary velocities the difference would be considerable. When we drew a circle on paper and determined the ratio of circumference to diameter, we found the well-known number π. If we placed a heavy particle at the centre of the circle, the result should be slightly greater than π. The space around that heavy particle was non-Euclidean; we might consider it Euclidean, however, and say that our measuring rod had contracted (or expanded) according as it had been placed radially (or transversely) to gravitational force. The consequences of the new law of gravitation were not likely to be put to any immediate practical test. But the theory had already had one striking success. If we could isolate the sun and one planet from the rest of the solar system, the planet should, according to the Newtonian law, describe an ellipse and repeat the same orbit indefinitely. According to the new law, that was not quite true; the ellipse would not quite close up, and the next orbit would be a new ellipse in a slightly advanced position, that is to say, the elliptic orbit would turn round slowly in the direction in which the planet was moving, and after centuries the orbit would point in a different direction. The fastest planet, Mercury (moving at 30 miles a second, Venus 22 miles, Earth 18½ miles) would show this best; the orbit of Mercury was more elongated than the others, moreover. Now it had long been observed that the orbit of Mercury advanced at the rate of 574 seconds of arc per century; 532 seconds were accounted for by the attraction of the other planets, but the remaining 42 seconds of arc, 30 times more than the probable error, had long been known as a celebrated discordance between observation and Newtonian theory. Now Einstein's theory predicted an advance of the orbit by a fraction of one revolution equal to three times the square of the ratio of the velocity of the planet to the velocity of light, and that worked out to 43 seconds of arc for a century.

Einstein's theory might possibly be tested also with regard to the action of gravitation on a ray of light. If all mass were electromagnetic, light as a form of electromagnetic energy should have mass, and indeed a ray of light acted on a surface on which it fell somewhat like a jet of water (radiation pressure). Measured in pounds and bought at the rate of the Board of Trade unit, 3*d.* per unit., the pound of light would cost 141,615,000*l.* But mass and weight were not identical, though they were aspects of the same thing according to Einstein, and whether light had weight as well as mass would have to be settled by experiment. A ray of light should be deflected like a bullet when passing an object exerting gravitational attraction. With the enormous velocity of light only the sun would be able to produce an observable effect. The light ray from a star close to the sun should be slightly displaced; that might be tested next year when the totally-eclipsed sun would be in a field of bright stars. The experiment might lead to one of three results: (1) A deflection amounting to 1.75 seconds of arc at the limb of the sun would confirm Einstein, but would be twice as great as otherwise expected; (2) a deflection of 0.83 second would prove that light had weight, but would overthrow Einstein's theory; (3) the absence of a deflection would show that light though possessing mass, had no weight, and hence the Newtonian law of proportionality between mass and weight would break down in another unexpected direction.

Einstein's theory, Professor Eddington said in the last part of his address, had been criticised as an attempt to explain gravitation. It did not pretend to offer any such explanation, nor even to hint at a possible mechanism; it only tried to explain space, *i.e.*, the scaffolding constructed from our measures. But, the lecturer added, after pointing out that a particle always took the path of least effort, the fundamental constants, gravitation, velocity of light, and the quantum of action, made it possible to form a new fundamental unit of length, 7×10^{-28} cm. That length must play a fundamental part in any complete theory of gravitation; in Osborne Reynold's theory of matter this unit appeared as the mean free path of the granules of his medium. Professor Eddington did not explain the deduction of this unit. But, he concluded, "until we can appreciate details of structure down to the quintillionth of a centimetre, the most sublime of all the forces of nature remains outside the purview of the theories of physics."

NOTES.

Military Aircraft.

In a paper published in a recent issue of the *Journal of the Franklin Institute*, Mr. W. F. Durand discussed some of the problems encountered in the development of fighting aircraft. Referring to the plan of firing safely through a revolving propeller by mechanism by which the gun is prevented from firing unless the propeller blades are clear, he said that this device was not always effective owing to occasional delayed ignitions. Hence blades were sometimes hit, but in general no great damage resulted. In exceptional cases, however, the injury to the propeller was serious. and might lead to disaster. Another method of firing dead ahead on "tractive" machines was to mount the gun on the upper plane so that it fired over the propeller but the gun was not then under such ready control. A third plan was to make the propeller shaft hollow and fire through it. This was only practicable when the propeller was gear driven, but this was now becoming desirable for other reasons since modern engines were being run at rates of revolution incompatible with the high efficiency of a direct driven propeller capable of absorbing the power developed. To get a good propeller efficiency it was, in short, desirable to keep down the speed, whilst to get a high development of power per lb. weight of the engine it was necessary to put up the speed of rotation. With the V type of engine the shaft of a geared propeller might be, he said, conveniently arranged between the two rows of cylinders In this way any desired gear ratio could be adopted, and by making the shaft hollow a path for the bullets was provided free from any possible

obstructions. As instancing the necessity of sound and rapid judgment in an aerial combat, Mr. Durand stated that if two opposing machines, 1,000 ft. apart were circling at 100 miles an hour round a fixed centre and on opposite sides of it, a bullet aimed directly at one machine by the other would go 120 ft. wide of the mark.

RECENT BOILER-ROOM PRACTICE IN AMERICA.

In a review of "Power Practice in 1917," contributed to *The Electrical Review* (New York), Mr. I. L. Kentish-Rankin describes the difficulties which have arisen from shortage of labour and from the necessity of using indifferent fuels; the situation being aggravated by an unprecedented demand for power and the impossibility of securing deliveries of new plant. The labour situation has, he says, gone from bad to worse. Managements that once chose labourers, when they should have selected chemists, now have to take what is available and to try and keep it. Labour has migrated to more pleasant and better callings, and it is suggested that greater attention to the establishment of more comfortable conditions of working will be necessary. Men must not be called on to do work which can be effectively accomplished by machines, and more attention must be paid to the ventilation and lighting of the boiler-room. Mr. Kentish-Rankin states that the underfeed stoker has proved of very great advantage in the conditions of last year, since it permits of very high rates of firing, enabling the output of the boiler to be increased in continuous running to 2¾ times the normal rating. Since additional boiler capacity has been practically unobtainable it has been necessary to take overloads by forcing the boilers, and underfeed stokers are now being used with fuels for which the chain grate type was previously considered essential. This has led to much trouble from clinker, but the dilemma before the station management was the adoption of a stoker which could at need work at four times its normal rating, but was liable to form troublesome clinker, or to use another type which gave little trouble in this regard, but could not be forced much beyond its normal working capacity. The clinker troubles have been aggravated by the necessity of using coals containing as much as 25 per cent. to 35 per cent. of ash and by the high temperatures resulting from the intense forced firing. As a result, ash pits have often proved of insufficient capacity, and with exits smaller than the lumps of clinker to be removed. The size of these lumps has been a source of much trouble. They are not easy to break, and the work is unpleasant. Mechanical ash conveyors which were formerly satisfactory have proved unequal to the new conditions. Moreover, there is much more trouble nowadays in the final disposal of furnace refuse. It is, Mr. Kentish-Rankin continues, being found profitable to increase greatly the number of instruments in use in the boiler-room. The demand for CO_2 recorders, steam and water meters, is unprecedented, and steps are being taken for the more careful instruction of the staff in their maintenance and use.

CYLINDERS FOR DISSOLVED ACETYLENE.

Whilst gases like hydrogen and oxygen may be stored and transported in cylinders under high compression, provided they be pure, acetylene is in itself explosive and is considered unsafe when exposed to a pressure of 2 atmospheres. Accidents having occurred abroad, the Order in Council of 1897 limited the pressure in acetylene cylinders to 100 in. of water, which limit was raised in 1914 to 250 in. of water. Meanwhile it had been discovered that acetylene could be compressed into certain porous materials, with or without the addition of a solvent like acetone, and such compression was legalised in 1912. The liquid acetone dissolves at ordinary temperature and pressure 25 times its own volume of gaseous acetylene, at 12 atmospheres it can dissolve 300 volumes, and at — 80 deg. C. even 2,000 volumes at atmospheric pressure. Such "dissolved" acetylene will bear 10 atmospheres, though at still higher pressures it is more dangerous than pure acetylene. Since November, 1915, several fatal accidents have occurred with cylinders of dissolved acetylene, all cylinders of 200 cub. ft. capacity and welded by the oxy-acetylene process. In October, 1916, the Home Office therefore appointed a Departmental Committee, which worked in conjunction with some of the interested companies and experimented both at Eskmeals, the Home Office Experimental Station, and at the National Physical Laboratory. From the report of the committee, issued last month, we see that three kinds of porous materials are in use: (1) A porous agglomerate of asbestos, kieselguhr and charcoal, together with a suitable cement —in itself an extremely good material, but of heavy weight, and difficult to fill in and still more to remove; (2) charcoal, of light weight and easy to fill in and to remove; (3) kapok (the seed hair of certain eriodendron), extremely light, but not so easy to remove as charcoal. The usual porosity of these latter materials, 80 per cent., should not be exceeded, according to the report, and the formation of cavities and pockets at the top of the cylinder, owing to the settling of the loose material, should be avoided as much as possible, though it was found that such gas pockets, when exploded by fuses, placed inside the cylinders, or by detonators, perforating the cylinder wall, did not give rise to a general explosion. As the war has created a strong demand for acetone, acetone substitutes, known as calcitone and carbitone, are used as acetylene solvents; these substances are earlier distillates of the acetone manufacture, and are used as such, or mixed with acetone. Their absorption capacity is inferior to that of acetone, and they will hardly survive the war, the committee consider, but may be tolerated for the present, provided that each solvent be used separately. Allowance must be made for expansion with rise of temperature, for which purpose the solvent should not make up more than about 40 per cent. of the cylinder volume. The gas pressure might be raised to 225 lb. per square inch at 60 deg. F., but only for solid-drawn cylinders and for those welded cylinders, in which flanges hold the top and bottom, so that the strength does not depend merely upon the weld; it was the weld which failed in all the accidents. The cylinder should be made of mild steel containing 0.25 per cent. of carbon and 0.05 per cent. of sulphur and of phosphorus as maxima; they should be tested at four times the working pressure for at least 15 minutes, and properly be annealed. The use of safety plugs, likely to be a source of weakness, is not recommended. Retesting might be confined to a thorough visual inspection, since neither the acetone nor the substitutes mentioned seemed to attack the steel; we notice, however, that some chemical action, due possibly to the charcoal or its impurities, seemed to have been observed in a few cases in which the cylinders became hot while the gas was blown-off. The results of the examination should be entered in the history sheet of the cylinders. The committee would prohibit all oxy-acetylene welding of the cylinders, as soon as the conditions of manufacture will permit, and withdraw all welded cylinders eventually from service.

MOTOR TRANSPORT OWNERS AND LABOUR.—A Motor Transport Owners' Federation has been formed; the Central Headquarters are at 83, Pall Mall, S.W. 1, and the secretary is Mr. Frederick G. Bristow. The necessary number of local associations are in course of formation throughout the United Kingdom, and one of the main objects of the federation is to bring into existence Conciliation Boards on the lines of the Whitley Report. It is recognised that the condition of industry obtaining at the conclusion of hostilities will necessitate harmonious co-operation between those who organise and those who carry out the operations, and the transport industry being vital to the prosperity of nearly every other industry, should be among the first to be organised.

ENGINEERS AND OIL.—At a meeting of the National Motor Cyclists Fuel Union on the 4th inst., at the Imperial Hotel, Birmingham, the following resolution was unanimously adopted: "That this representative meeting, comprising delegate members of the National Motor Cyclists Fuel Union, and consisting of engineers who are foremen, shop stewards, and leading hands in aero-engine, motor shipbuilding and other engineering factories engaged on war work, pledges itself to do all possible by personal effort to economise in the consumption of petrol, paraffin, lubricating oils, grease and other imported petroleum products, in order that more shipping space may be available to bring food into the country, and the fuel provided to distribute it by road motors."

THE PHYSICAL SOCIETY OF LONDON.

At the meeting held on January 25 at the Imperial College of Science, the presidential address was delivered by Professor C. V. Boys, F.R.S. He said that the exigencies of the war had seriously impeded the work of the Physical Society, as of all our scientific institutions. Many members were at the front; many others were busy on war work, and there was little time available for normal scientific pursuits. Since his predecessor's address, the scientific community had been stirred to an extent which he thought was unnecessary by the passing of the Daylight Saving Act. Scientifically the thing was a sham, and as such was naturally distasteful to us; but the community at large was not scientific, and had a very vague notion of the meaning of time. In the stress of war the public had realised the desirability of starting the day earlier to save not daylight but paraffin and gas, and the simple operation of putting all the clocks wrong, though hateful in principle, did not disturb the public at all.

In reference to the question of the metric system, this was important in relation to education. He believed the reason why English schools were so backward in mathematics was that so much of the available time had to be devoted to memorising tables of weights and measures and similar medieval relics.

Another matter of public importance was the recognition of science as an element of general education. It was sometimes urged that our officials need not be scientific, because they could get all the scientific advice they wanted. But they might not know when they required it, or appreciate the force of it when they got it. He might instance in this connection the wasteful method of street darkening which still prevailed after three years. The annual trouble with frozen water pipes was another example of the general ignorance of scientific principles. Burst pipes were unknown in really cold countries, where the elements of common sense were allowed to prevail.

All his own contributions to physical science had been experimental, and some words on the art of experiment might not be out of place. In order to succeed as an experimentalist it was necessary to find by personal experience how as many materials as possible behave under as many conditions as possible, and this could only be done by one who would practise every art and use every tool and instrument that he could. While endeavouring at first to imitate the practices of the professional mechanic and acquire as much of his skill as possible, the experimentalist must not be bound by tradition and custom in his methods. It was the slavery to tradition and practice that made the assistance of the professional so tiresome to the experimentalist. In this connection a saying of Fresnel had greatly impressed him: "If you cannot saw with a file and file with a saw you will be no use as an experimentalist," or words to that effect. He had made it his business to use every tool and to handle every material that he could. On one occasion he had had the somewhat rare opportunity of handling five or six large uncut diamonds, each as big as a walnut. Glass blowers are familiar with the difference in the contact of freshly-blown bulbs and of bulbs some time blown; but the contact of diamonds was unlike either. When brought lightly into contact they emit a curious squeaking note of possibly 2,000 vibrations per second. This meant that the diamonds were bouncing with slowly diminishing excursions of 1/80,000 of an inch approximately, a phenomenon only possible with a material of such perfect elasticity or hardness. It was possible that a test of this kind might be useful for discriminating between the hardness of the harder materials. The whole question of what hardness was, and if, indeed, it were really a definable quantity having definite dimensions, was one to which the attention of physicists could profitably be diverted. Another such question was that of the oiliness of lubricants. This appeared to depend on something other than viscosity. Animal and vegetable oils lubricated better than mineral oils of the same viscosity.

BOARD OF TRADE ANNOUNCEMENT.—Sir H. Llewellyn Smith, Permanent Secretary to the Board of Trade, has undertaken a special mission on behalf of the Government. He is accompanied by Mr. H. Fountain, of the Commercial Relation and Treatise Department and by Mr. Walter Carter (Private Secretary), and will be absent from the office for some weeks.

SEWER-SIPHON OF FERRO-CONCRETE AT THE HAGUE.—The sewers of the political capital of the Netherlands, The Hague, are, after purification, discharged into the North Sea near Scheveningen. As the many canals of the district cut into the level of the underground water, the conduit has had to be laid with several up-gradients. Under those conditions the maintenance of the drainage flow required either the application of pressure or the use of siphons. During recent improvements of the drainage, we see from a long article by Mr. F. C. I. van den Steen van Ommeren, in *De Ingenieur* (1917, pages 252 to 264), siphons, 2 m. in diameter, of ferro-concrete, were adopted. As ferro-concrete is not airtight, and as air must not be allowed to infiltrate into the siphon, a cylindrical shell of sheet iron was embedded in the concrete. This shell has a thickness of 1.5 mm.; the joints are covered by strips and welded to them; the conduit was laid in sections of 4 m. length, which overlap by about 20 cm.; expansion joints are provided at distances of 250 m. The whole concrete conduit has a length of 2 km. The concrete layer inside the shell has a thickness of 17 cm., the thickness of the outer layer is 3 cm.; rings and spirals of iron are further embedded in the concrete to increase its strength.

INDUSTRIAL NOTES.

The Engineering and Shipbuilding Trades Central Advisory Committee (Operatives), which advises and assists the Ministry of Labour on questions arising in the administration of the Employment Exchanges, which affect workpeople in those trades, held their fifth meeting at 2.30 p.m. on Tuesday, January 29.

In connection with a suggestion that Labour Advisers should be appointed in the Divisional Offices of the department, the committee were informed that it was the view of the department that the necessary advice and information would be obtained from the members of the Local Advisory Committees. The committee accepted this decision and, after an explanation of the work which will be undertaken by the Local Advisory Committees in the area of each exchange, expressed satisfaction at the appointment of such committees. It was further explained that if any matter of difficulty arose locally in connection with the working of the exchange, the appropriate means of adjusting it would be by means of the Local Committee.

The committee, among other subjects, discussed the provision of special rooms for interviewing applicants at Employment Exchanges, and finally resolved to ask the department to provide such rooms for interview in all special cases where a separate interview is necessary. They also agreed to impress upon the department the importance of securing good buildings in good situations for the Employment Exchanges.

The following are some of the recent decisions given by the Committee on Production and the Special Arbitration Tribunal on cases which have been referred to them by the Ministry of Labour, including cases arising out of the Orders under which a bonus to munition workers has been given: Messrs. Kynoch-Arklow, Limited, engineers, plain time workers, receive the bonus of 12½ per cent. on earnings. Railway shopmen, skilled, semi-skilled and unskilled, are plain time workers employed on munitions work (including the repair, maintenance or construction of locomotives, carriages, or wagons), in the railway companies' shops, and are entitled to the 12½ per cent. on earnings. As regards classes of men other than plain time workers, the tribunal decided that a bonus of 7½ per cent. on earnings should be paid as from the first pay day in January, 1918. Messrs. Asa Lees and Co., Limited, iron founders, are piece workers employed on munitions and commercial work, and will receive a bonus of 7½ per cent. on earnings as from the same date. Men in the wire-rope trade are engaged on both munitions and commercial work, and the plain time workers receive a bonus of 12½ per cent. on earnings as from the same date. Shipbuilding trade piece workers, &c., are not plain time workers, and are therefore not under the Statutory Orders; the decision is that the men shall receive a bonus of 7½ per cent. on earnings as from the first pay day in January, 1918; in the case of platers and angle-iron smiths, the increase of 7½ per cent. is to be added to the net earnings of the men concerned, *i.e.*, the earnings after deduction from the gross bill of the amount paid by them to their helpers and strikers. Barge builders are plain time workers, and receive a bonus of 12½ per cent. on earnings as from the same date.

The Secretary of the Ministry of National Service authorises the following statement: Sir Auckland Geddes has issued invitations to all the trades unions, which were invited to the series of conferences held last month, to send representatives to meet him in general conference to-day. The meeting will be held at the Central Hall, Westminster, at 11.30 a.m.

Owing to shortage of raw materials and other causes the number of unemployed in Denmark is increasing very rapidly, and strenuous efforts are now being made to procure employment, efforts in which the State, the different municipalities and the leading banks have combined. At the end of the first week of January there were in Denmark about 41,000 organised hands without employment, in addition to several thousand unorganised hands. The different banks have now agreed to lend the various municipalities a sum of about 30,000,000 kroner, for which loans the State is expected to pay at least part of the interest. The State will also be asked to increase its grant to the unemployment societies.

In Norway there is at present no great unemployment, but such is expected in the spring. The iron industry, by reason of shortage of raw material, has been compelled to give a number of notices, but not to any great extent; in the textile works there is no lack of raw material, but a shortage of labour in some departments. The building industry suffers seriously from want of materials, and almost all private building undertakings have come to a standstill; the different municipalities, however, are building on a large scale, so that the men in the building trades have employment. The boot and shoe trades are short of imported material, which greatly hampers and limits manufacture.

In his address before the Commercial Club of Chicago, on January 5, Judge Gary, says *The Iron Age*, New York, pointed out that the country cannot take advantage of its natural resources without having men in sufficient numbers in the workshops. He expressed the opinion that to meet the present emergency the United States should immediately, under proper conditions and reasonable restrictions, draw from the islands of the sea and from oriental countries enough men, including soldiers and sailors, to meet every demand. He insisted that winning the war was the paramount consideration. Judge Gary had no doubt in mind, adds our contemporary, the millions of brown men in the Philippines who are believed to be loyal to the United States, and who could be used as soldiers, sailors or workmen to help win the war against the Central Powers, but it is also probable that he had in mind the employment of natives of China, as is already being done on an extensive scale behind the battle line in France. His position will, of course, be assailed by labour agitators, and many other people will dissent, but if these objectors are asked how they propose to obtain enough men to do the manual work connected directly with the war and to fill the places of the men who have been or will be called to the colours, they will not easily find an adequate answer.

It is interesting to note in this connection, our contemporary further states, that the California State Development Board is favouring the importation of experienced Chinese farmers to California for the period of the war. When any organisation in California is willing to admit Chinamen even temporarily, a decided change of sentiment has taken place.

The proposed mobilisation of 3,000,000 workers for agricultural, shipbuilding and war contract plants, which has been inaugurated by the Department of Labour through the United States Employment Service, will probably accomplish very desirable results. Until this and other plans have been tried, it is not likely that Congress will adopt Judge Gary's suggestion, but if the war should continue for two or more years, it may be compelled to do so.

In the course of an address he delivered last Monday evening before the members of the Birmingham Business Club, Professor Kirkaldy stated that to win the war the Government were asking for another 250,000 men, and this demand had to be faced. It was no use having flourishing industries if Germany was to win; we had to win the war, and a long step towards this was in supplying the number of men asked for. He was certain a sufficient number of men could be found, and he took it for granted that we were not going to have a German peace.

We had also to consider what steps could be taken to consolidate our position, so that when peace came we might have a healthy development in the true interests of all sections of the community. When war broke out we were working in a vicious circle. Professor Kirkaldy added that he deprecated class war, and he urged that employers and workmen should work together. Instead of looking at the wages book the employer should look at labour cost. It did not matter if a man took home 5*l.* or 10*l.* a week so long as the labour cost was low—most employers knew that low-paid labour was expensive labour; it was the best-paid labour that led to the least labour cost. When war broke out there was an industrial force of men and women in this country of over 8,000,000. Women came in to help to the extent of 500,000, and the three factors which had produced the miracle of the increased supplies were firstly the patriotism of the men and women who had come forward; secondly the scrapping of old methods and machinery, and the installation of the latest methods and newest types of machinery; thirdly, the trades unions allowing, for the period of the war, the machinery to be used to its utmost capacity, members and non-members to work for all they were worth.

Even if matters have not quite come to such a pass as in Russia, the employers in Finland are loud in their complaints. They suffer from heavy, often exorbitant rises in wages, and at the same time a deterioration of the quality and a diminution of the quantity of the work put in. The men often decline to work full hours. The first reduction took place towards the end of May, when the hours were reduced to eight, the old wages being maintained. Since then wages have been raised several times and were, on the whole, towards the end of November, three times as high as a twelvemonth ago. These increases in wages may not in themselves have been so unreasonable, and have in many cases been granted with good grace, and without the men having had to resort to a strike. But these higher wages have, in many cases, caused the men to be extravagant, and as a matter of fact many officials, who formerly enjoyed a higher standard of life than the men, now manage with considerably less than does a workman. The men, on their side are always crying out about the high prices and asking for increased wages. During the first year of the war a man, on piece pay, produced on an average 800 pieces of a certain article in 6½ hours, which was the daily requirement. When time pay was introduced the same man, in 10 hours, produced 640 pieces, and during the summer of 1917, after the adoption of the eight-hours' day, an average of 460 to 465 pieces per day. Many similar examples could be adduced, and the Industrial Council has been recommended to collect more exhaustive statistics on the subject.

A correspondent has written to *The Times* stating that much educational work is being done in the Army, and in one large area a definite scheme has been drawn up and is actually in operation, having as its admitted objects:—

1. The development of intelligence, initiative, self-control and discipline.
2. The widening of outlook and the fostering of imagination.
3. An increased power of co-ordination between mind and body.
4. The foundation of a faculty of reasonable self-expression and an ability (*a*) to grasp ideas and situations rapidly and fully, (*b*) to reason logically.

These aims have more than a direct military value, and if they can be attained, the nation as a whole will benefit enormously thereby.

The salient feature which strikes anyone who hears one of the lessons is the extraordinary attention and interest displayed by the young soldiers. They sit, often wearing their equipment, and with their rifles between their knees, listening with such rapt attention to the teacher, usually one of their own officers or non-commissioned officers, that even the entry of an inspecting general fails to disturb them. Such enthusiasm is not confined to the men. Generals, battalion commanders and officers have all entered into the spirit of the scheme with the intensest energy, and many formations have extended their activities beyond the limits which were originally intended. Voluntary classes held in the evenings are never short of willing and eager students. Advantage has been taken of facilities for technical, trade and commercial instruction wherever it could be obtained, and a special effort has been made to provide such instruction for those men whose industrial training had been interrupted by their enlistment.

Association of Engineering and Shipbuilding Draughtsmen: Tees-side and Hartlepools Branch.—The annual general meeting of the above branch was held at Stockton-on-Tees on January 26, 1918. A large and representative body of draughtsmen in the district were present. The president, Mr. H. H. Lowe, congratulated the members upon their grand muster, which, he said, in itself proved the interest the members were taking in the association. He pointed out the advantages that had already accrued from this association in bringing men together. He paid a high tribute to the district secretary, who was responsible for the excellent position of the branch. Dealing with the work of the local branch and the association as a whole, he was able to place a very satisfactory analysis before the members present and drew attention to the excellent work already undertaken by the new general secretary. The president spoke at some length on the present and future policy of the association, and drew the attention of the members to two vital points of interest to draughtsmen, viz., the introduction of female labour and the increase of juniors in drawing offices, and invited the senior men to give this their careful attention. He expressed the hope that it would always be possible to avoid trade-union methods and pleaded for the maintenance of the present staff relationship between men and employers, bearing in mind the fact that pre-war conditions were a thing of the past, and a new situation would have to be faced after the war, and new values established. The president concluded his address, which was closely followed by the members present, with an appeal to all draughtsmen to help the association forward and to make the Tees-side and Hartlepools branch one of *the* branches in the United Kingdom. The secretary, Mr. G. Maxwell Wilson, in his report, stated that there had been a steady influx of members during the past year, and it was gratifying to find the membership was being maintained despite the increased subscription. Excellent results have been achieved considering the short time the association has been in existence. Several resolutions were put before the meeting and passed, after which the election of officers took place, the result being:—President, Mr. H. H. Lowe, Middlesbrough; vice-president, Mr. Wm. Clark, West Hartlepool; secretary, Mr. G. Maxwell Wilson, Stockton-on-Tees; treasurer, Mr. Arthur F. Wright, Thornaby-on-Tees; auditors, Mr. G. W. Hodgson, Middlesbrough, and Mr. J. S. C. Kirtley, Stockton-on-Tees. Votes of thanks were accorded to the retiring officers. Questions were invited, and an animated discussion took place on various matters of interest.

"A SIMPLE PROBLEM IN FORCED LUBRICATION."

TO THE EDITOR OF ENGINEERING.

SIR,—Four years ago, in writing a note for the second volume of a work of mine on the construction of engines* it was recalled that Reye's assumptions for the frictional resistance in bearings had only the merit of affording a simple means for deriving practical formulæ, and it was also remarked† how undesirable it was to borrow an uncertain hypothesis from an old theory of wear when Beauchamp Tower and Osborne Reynolds had long since demonstrated the character of the pressure and of the friction in ordinary journals. As to pivots I observed that practical considerations on their *running conditions* pointed to a variation of the pressure *inversely as the radius*.

From the clear and comprehensive article recently contributed to your Journal by Lord Rayleigh we learn the scientific law for the distribution of pressure on footstep bearings, and trust that Continental professors of engineering will no longer speak of the old hypotheses.

May I now venture to suggest that the pressure of viscous lubricants in footstep bearings is really inversely as the radius if only the viscosity itself decreases as r_0/r so that the equation of the pressure comes to

$$\frac{d\,p}{d\,r} = -\frac{C\,\mu_0\,r_0\,U}{\pi\,h^3}\cdot\frac{1}{r^2}$$

The assumption $\mu = \mu_0\,r_0/r$ hardly calls for justification in practice. In a number of existing plants the rise of temperature of the oil is such as practically to thin down the oil and reduce its viscosity in the ratio r_0/r_1.

To come to figures, large footsteps for heavy vertical turbines have $r_0/r_1 = \frac{1}{2}$. If they be lubricated with thick oil and the feed is such as to permit 10 deg. C. rise of temperature in the oil, the viscosity will be halved. Lubricants as light as olive oil require a rise of 31 deg. F. (17 deg. C.) to halve their viscosity according to Osborne Reynolds' equation

$$\mu = 0.00004737\ C^{-\,0.0221\,t}$$

in British units.

If we now consider ordinary footsteps with rather small reservoir wells ($r_0/r_1 = \frac{1}{4}$ to $\frac{1}{3}$) running at not very low velocities, we see that the approximation $\mu_1 = \mu_0\,r_0/r_1$ is practically fulfilled by the final condition of the oil. Some relative figures as to the variation of viscosity with temperature are given below for a heavy oil.

Russian Thick Oil.

Temperature (deg. C.)	...	20	28.5	33.5	37	40
Viscosity (Water = 1)	...	68	34	23	17	14
Ratios (μ_1/μ_0)	...	...	1	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{3}$

We need not add that the relation above suggested has not yet been proved true throughout the entire range of the variation in the viscosity of the lubricant, but it applies well to the conditions at both boundaries, and, moreover, it offers the great advantage of taking into consideration the *unavoidable thinning of the oil*, and therefore leads to more reliable results than the assumption of a constant viscosity. For example, the *pressure of the feed* corresponding to r_0 comes out to be 40 per cent. more than given by μ constant when $r_0/r_1 = \frac{1}{2}$; and it would be more than twice as much in the extreme case $r_0/r_1 = \frac{1}{10}$. For $r_1/r_0 \gtrless 2$ one arrives at practically the same values.

Towards the end of the article there is a statement worth serious consideration: "It should be observed that no property of oil beyond viscosity is involved, and that the investigation may be expected to remain valid until the thickness of the layer is approaching molecular limits."

Now, the thinning of the oil in modern engines has gone down from $\frac{1}{1,000}$ in., as found by Osborne Reynolds in the Tower bearing, to $\frac{1}{10,000,000}$ in. (one ten-millionth inch) as found by us in applying the interesting calculations on the lubrication of gear teeth given in ENGINEERING, August 11, 1916, to the most strained wheels which we could find in Italian motor cars.

Theory and practice are calling for still more audacity in modern well-built machinery.

Yours faithfully,

OTTORINO POMINI

(Technical Director of the Works Luigi Pomini–Castellanha).

January 21, 1918.

GERMAN METHODS OF GAS-ENGINE DESIGN.

TO THE EDITOR OF ENGINEERING.

SIR,—It is rather astonishing to me how slavishly the German method of calculating the cylinder sizes of gas engines is followed in this country. As you are aware, a certain thermal efficiency is assumed, a certain volumetric efficiency is assumed, a certain mechanical efficiency is assumed, a certain rate of fuel consumption is decided upon and on that basis, with these assumptions the size of the engine is determined. Except as a concealed function of the thermal efficiency neither compression nor mean pressure enters into the calculation. It is quite overlooked that mechanical efficiency covers and provides for volumetric efficiency.

Under these circumstances it is not surprising that some attempts to follow the method made by those who have not the accumulated experience and practice of a gas-engine building establishment to fall back upon, have resulted in figures not at all like what could be considered a fairly close result.

My object in writing now is to point out that the only assumption that requires to be made in determining the sizes of gas engine cylinders is the mechanical efficiency. It is my firm belief that for every engineer who can make a close guess at the thermal efficiency of a contemplated new design of gas engine there are a hundred engineers who could make a better guess at its probable mechanical efficiency.

Twenty years ago I formulated for my own use a method in which mechanical efficiency is the only assumption made, and in which compression pressure and mean pressure are made use of distinctly and quantitatively. I do not believe there is any other method that will give as close an approach to the actual mean pressure in the cylinder of a gas engine as this method will give:

$$(1)\ \text{MEP.} = 3p\left(\frac{C}{15\left(\frac{C}{U}+1\right)}-1\right)\left(1+\frac{v}{s}\right)\left(\sqrt[3]{\frac{v+s}{v}}-1\right)$$

Where p = atmospheric pressure in pounds per square inch.
v = clearance expressed as a fraction.
s = stroke expressed as unity.
C = calorific value of the gas in British thermal units per cubic foot.
U = number of heat units to be used for cubic foot of stroke volume.
and MEP = mean effective pressure in pounds per square inch.

$$(2)\qquad \text{TE.} = \frac{\text{MEP. } 144\ \text{ME.}}{\text{U } 778}$$

Where M.E. = mechanical efficiency
and T.E. = thermal efficiency (brake)
} as fractions.

$$(3)\qquad G = \frac{2545}{\text{C. TE.}}$$

Where G = gas consumption in cubic feet per brake horse-power hour.

$$(4)\qquad \text{SV.} = \frac{2545\ \text{BHP. } 2}{\text{U. TE. N. R.}}$$

Where B.H.P. = brake horse-power required.
N = number of single-acting four-stroke cylinders.
R = number of revolutions per minute.
and S V = stroke volume of one cylinder in cubic feet.

When a gas engine is adjusted to work at its most economical load, i.e., when it is operating at its highest thermal efficiency, it will be found that 50 British thermal units per cubic foot of stroke volume are passed into the cylinder.

When a gas engine is working at its maximum load possible with the particular gas used, it will be found that 60 British thermal units per cubic foot of stroke volume are passed into the cylinder.

Yours truly,

JAS. DUNLOP.

190, Bellfield-street, Dennistoun, Glasgow,
January 29, 1918.

PATENT LAW REFORM.

TO THE EDITOR OF ENGINEERING.

SIR,—Referring to recent correspondence in ENGINEERING on this subject, it may be of interest to your readers to know that both the New Patent and Designs Bill and the New Trade Marks Bill have now been dropped till next session of Parliament. I trust they may be dropped for good till the war is ended. The New Trade Marks Bill is equally bad with the New Patent Bill, so bad, in fact, that *The Daily Chronicle* has termed it "mischievous" and has suggested that the only way to amend it was to "amend it out of existence"; the authors of both Bills would appear to have learned nothing from the failure of the previous or present Acts, though the injury inflicted on British trade and invention by these Acts ought by this time to have been fully appreciated. As regards the Merchandise or Trade Marks Act at present in force, no other country in the world is inflicted with such a foolish Act for the purpose of advertising and exploiting the wares of its competitors. If we are to have new Acts for patents and designs and trade marks during these strenuous times, let these Acts be progressive and democratic, and not as suggested by the new Bills now withdrawn for the time.

Might I venture to call attention to the able speech made a week or so ago by Mr. H. H. Asquith, M.P., on the "Problems after the War," in which the right honourable gentleman pointed the way by stating that we in this country ought "to welcome and to help each fresh advance on the road to progress," and, he particularly showed how this could only be done "by education, by science, by organisation, by inventiveness, by flexibility, and by strenuous toil." Mr. Asquith has the reputation of invariably using the right words; thus, "inventiveness" requires no explanation, and "flexibility" means the opposite of "rigidity" or "red tape."

As regards patent law reform generally: It does appear to me that the whole question ought to be left over until after the war, and that then we ought seriously to endeavour, in conjunction with our Allies, to frame a patent law which would be practically uniform among the Allied States. It is not at all necessary that one patent should cover a number of countries, although the formalities for foreign applications might be made identical. Apart from this, however, I think that the fees should be very substantially reduced, that there should be no renewal fees, and, that supposing the Allies do decide to require payment of renewal fees, then these should simply be such as to leave the Patent Office self-supporting. There are no renewal fees required under the United States' Patent System. Inventors who make profits out of patents are caught first by the income-tax and secondly by the present excess profits tax in this country, and I see no reason why they should be taxed again by having to pay renewal fees which do not do them any good at least.

There should also be a proper system of examination involving not only investigation of prior patent specifications, but also investigation of the literature in the Patent Office library. For my own part I do not believe in the utility of any requirements relating to compulsory working, and I have yet to be convinced that it pays to impose requirements; the United States have proved for over eighty years that there is no necessity whatever for compulsory working; we, however, unfortunately copied in principle compulsory working from Germany for the first time in this country in the 1907 Patent Bill, hence our many troubles since. If, again, one has to manufacture the patented article in every little tinpot State where a patent is held, then, in fact, industrial organisation is out of the question. There is no use in talking about reorganisation after the war if patentees are going to be compelled to manufacture only on a small scale in each country.

If and when the patent laws come to be revised, it will be most inadvisable to confer excessive powers on officials, and it is desirable that officials should only be appointed for a limited number of years. We have had some brilliant law officers in the past, but no one who knows would care to say that some of these officers were anything like brilliant in technical matters. It goes without saying that everyone interested desires some scheme for simplifying procedure in infringement cases before the courts. I have never been able to see why so many formalities should have to be gone through as to require an army of solicitors and barristers and expert witnesses to settle some point which can be understood clearly from half-an-hour's study.

My excuse for so earnestly calling attention to this important matter of Patent Law Reform, is, that for over thirty years I have laboured in season and out of season in the Press and otherwise to bring about some reform of the British patent system, which I may truly say has, in my opinion, been iniquitous towards British invention, trade and progress.

Yours, &c.,

JAMES KEITH.

February 2, 1918, London.

SHIPBUILDING IN NORWAY.—A new shipyard is about to be put down at Kragerö. The capital has in the meantime been fixed at 2,000,000 kroner, and suitable sites for docks and shops have been purchased.

EXAMINATIONS IN SCIENCE AND TECHNOLOGY.—The Board of Education has decided to discontinue the general examinations altogether after 1918. The higher general examinations will be held in that year, with the exceptions specified in Circular 970. The regulations and syllabuses which governed the examinations held in 1915 will remain in force for 1918, so far as they are still applicable.

THE SHEFFIELD ASSOCIATION OF METALLURGISTS AND METALLURGICAL CHEMISTS.—The opening meeting of the Sheffield Association of Metallurgists and Metallurgical Chemists was held at the Royal Victoria Hotel, Sheffield, on Monday, February 4, 1918, at 8 p.m. Dr. W. H. Hatfield, president, delivered the opening address. The conveners of the different sub-committees then reported progress upon the work accomplished with regard to the headquarters and library, the proceedings and the business side. A general discussion then ensued, which was opened by Dr. J. E. Stead, F.R.S., of Middlesbrough (vice-president of the Iron and Steel Institute). Dr. Stead gave his good wishes to the association, and thought that the creation of a club in connection with a scientific institution was unique for the provinces, and he wishes the council every success in their venture. Mr. Arthur Balfour (past-president of the Sheffield Society of Engineers and Metallurgists) called the attention of the association to the new building which it was proposed to erect in connection with the Cutlers' Hall for the housing of the Sheffield Chamber of Commerce. He thought that in carrying out the scheme it would be an admirable plan to provide accommodation for this new association. Mr. Rossiter Hoyle (past-president of the Sheffield Society of Engineers and Metallurgists) said that he heartily agreed with the whole of the aims and objects of the association, and he was sure that his firm, Messrs. Thomas Firth and Sons, would give thorough, cordial and heartfelt support to the movement. Mr. Clarke (director, Messrs. Vickers, Limited) said that he could only join Mr. Hoyle and Mr. Balfour in the remarks which they had made with regard to the general support which the association would receive from the manufacturers of the district. In reply, Dr. Hatfield, on behalf of the council, expressed their appreciation of the excellent support they had received that evening, not only from the members but from the manufacturers and representatives of the university and other scientific institutions. The hon. secretary is Mr. G. R. Bolsover, 31, Rossington-road, Brocco Bank, Sheffield.

* "Costruzióne di Macchine II, ed. Ulrico Hoepli Milano.

† §2, at page 6; and "Nota Critica I" at pages 703 to 707.

THE WEST QUAY OF MADRAS HARBOUR.*

By Sir Francis Joseph Edward Spring, K.C.I.E., M.Inst.C.E., and Hugh Henry Gordon Mitchell, M.Inst.C.E.

The object of the paper is to describe how at a cost of 200,000*l.* 3,000 lineal ft. of a quay, fit for vessels of Suez Canal draughts, has been constructed along the west, or shore, side of Madras artificial harbour.† The quay in question has replaced the shelving, sandy shore, and, by allowing dredging to be done, has enabled the port authority to enlarge the area of the enclosed harbour, available for shipping, from about 100 acres to about 200 acres. In other words, the shore half of the harbour, which before the construction of the quay was available only for small craft, is now available for vessels of Suez Canal draughts.

The quay is constructed mainly of granite cement, concrete faced with granite masonry. It rests on about 70 double-aperture wells or monoliths, sunk to a depth of 55 ft. below low water, or to a depth of 23 ft. below the dredged bottom of the deepest berths. Of the wells 21 are 50 ft. by 28 ft., 3 are 44 ft. by 28 ft., 21 are 43 ft. by 24 ft., and 19 are 35 ft. by 20 ft. Besides 64 deeply-sunk, or regular, wells, there are at each end a few smaller and shallower wells, where the quay crosses the rubble base of the old harbour breakwaters. Throughout the full length, 2,980 ft., of the quay, its breadth, on top of the wells, is 24 ft. Its height above Indian spring low water is 12 ft. The wells are shod at the bottom with steel curbs weighing in the aggregate about 1,000 tons, made by local firms.

The strata through which the wells were sunk is sand or clayey sand, real clay not being met with until a depth of 77 ft., and rock not until a depth of 113 ft., is reached. The paper describes fully the principal mistakes that were made and the difficulties encountered during the progress of the work, showing how they were corrected or overcome. All the wells leaned forward 4 in. to 8 in. as the sea-bed was dredged from the fronts of them and the earth-pressure came on at the back. This forward movement, once it was fully recognised and diagnosed was compensated for by leaning the wells backward with a batter in the sinking, so that by the time the superstructure came to be built the top face of the line of wells was about 6 in. back from its ultimate position. An interesting feature of the work was the manner in which the space, averaging 1 ft. 8 in., between adjoining wells was sealed so as to prevent the flow of sand from the back. Another point of interest was the way in which the fronts of the wells were coffer-dammed so as to enable the true face-line of the superincumbent masonry to be wrought.

The paper gives very fully the accurate cost and unit rates of all the parts into which, for accounts purposes, the work was divided, and explains that these were not contractor's rates but the actual rates at which the work was executed, for the most part by daily, or departmental, labour, supplemented by a petty contract for the stone quarrying. The all-over cost of the finished quay—in spite of war prices for a part of the cement used—ran to practically Rs. 1,000, or 66⅔*l.* per lineal ft.

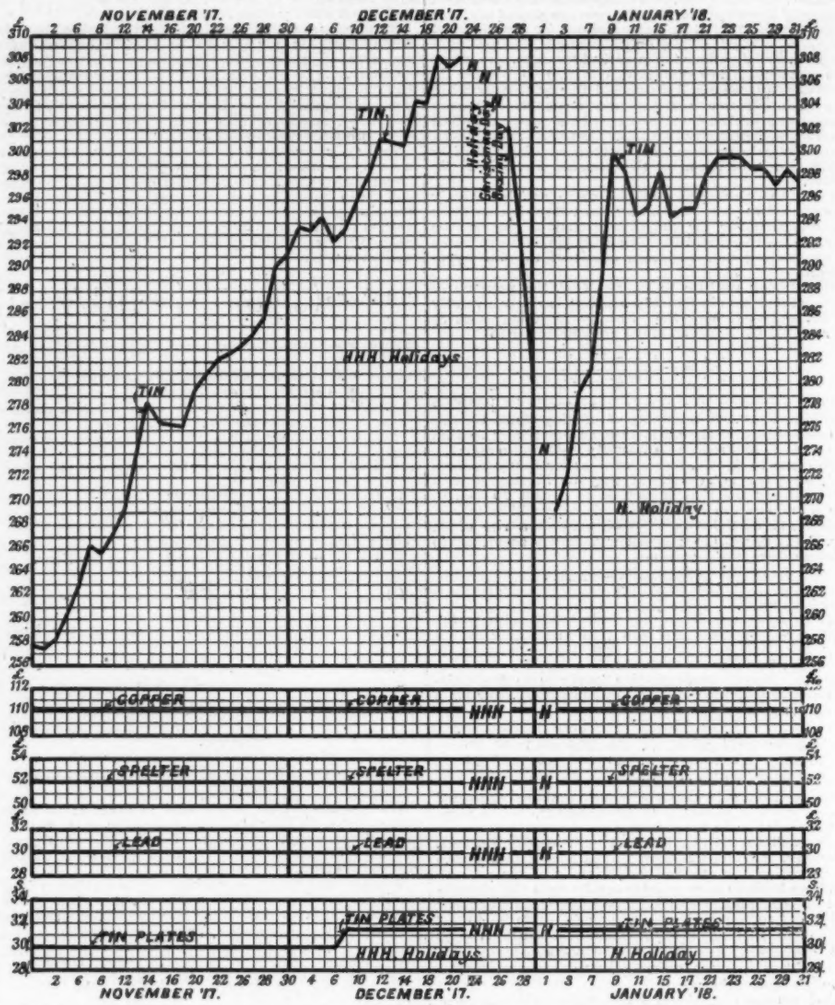
The quay is equipped with five groups of 1-ton hydraulic cranes for working cargo in and out of lighters at the places which ordinarily will be free of steamers. Overhead, or portal, 35-cwt. hydraulic cranes for plumbing ship's hatches are under order, but are delayed because of the war. The quay affords berthing for four steamers of the average Suez Canal class; or, in an emergency, when some of the groups of small, or barge, cranes will be masked, for six smaller vessels. Trains of both the South Indian gauges (5 ft. 6 in. and 1 m.) have access to the full length of the quay, which is equipped throughout with transit sheds 120 ft. wide, placed 112 ft. back from the quay face. The quay has already been used extensively, even when only half finished. Pending the instalment of cranes, its working capacity has varied, ship's own derricks only being used, from 1,200 tons in a day for coal down to 500 tons in a day for rails per steamer.

* Abstract of a paper read before the Institution of Civil Engineers on Tuesday, February 5, 1918.

† The authors have previously described this harbour in papers published in vols. cxc and cxciv of the Minutes of Proceedings, Inst.C.E.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



Note.—In the diagram above the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, as far as they have been reported, for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. The prices are per ton. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each. On July 7, 1916, the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6*d.* per ton. These quotations are still in force. (For official regulations see page 45, vol. cii.)

Price of Coal for Shipment.—A revised Code of Directions as to the sale of coal has been issued by the Controller of Coal Mines, to take effect as from the 1st inst. The new directions are in substitution for those made on June 28 last and amended on October 12. The main alteration is in regard to the method of payment for shipments to Norway, Sweden, Denmark, Holland and Spain. Sellers to these countries must in future quote to buyers abroad prices in the various foreign currencies in accordance with the schedules of prices appended to the directions, and must apply for payment to the Board of Trade, who will pay the seller in sterling and obtain payment in turn from the buyers abroad in the foreign currencies through accredited agents of His Majesty's Government in the various countries. The directions prescribe the rates of exchange to be observed in the case of sales made after January 31. In the case of shipments under existing contracts the arrangements as to payment abroad through the Board of Trade apply, but the buyer abroad is to make payment at the current rate of exchange.

The Röntgen Society.—Two novelties were exhibited at the meeting of the Röntgen Society on February 5. The first apparatus, described by Dr. G. B. Batten in a paper on "A Simple Means of Obtaining Static Modalities from an Induction Coil," dealt with the use of static electricity for the treatment of neuritis, &c. That utilisation had long been neglected, but had been taken up in America, where static machines afforded a more reliable source of static currents than in the damp climate of England. Dr. Batten hence tried induction coils, the point being to reduce the amperes while keeping the volts high. His secondary, whose one pole was earthed, was of high resistance, and a series condenser, consisting of four sheets of tin-foil separated by glass plates, was further introduced into the secondary circuit; this condenser, as Dr. G. W. C. Kaye, the president, pointed out, served as resistance. Dr. Batten had first worked with liquid resistance. The free electrode of the secondary was held by the patient sitting on an insulating stool or was held close to him, and the "six modalities" concerned various ways in which the current was applied for static bath, static brush discharge, wave current, &c. A strong brush discharge, a static breeze, is one of the chief aims of such apparatus. Mr. J. Blake mentioned that he had designed a similar apparatus in 1911 with a resistance of alcohol containing 7 per cent. of water. In the second paper, on "A Mobile Snook Apparatus," Mr. E. E. Burnside described a portable form of X-ray apparatus, the combination being that which Mr. Clyde Snook introduced ten years ago, consisting of (1) a rotary converter (fed from continuous-current mains), (2) a transformer receiving current from the revolving armature through slip rings, and (3) a rectifier, a rotary disc with contact arcs, the revolving parts being all on the same shaft; the reversal of the alternating current wave takes place approximately at zero potential. When alternating currents were available, the advantages of which were now recognised, Mr. Burnside stated, the converter was replaced by a synchronous motor. The War Office had first preferred induction-coil to transformer working, and there had indeed been considerable trouble with the early Snook apparatus because they utilised the full rectified sine-curve wave and heated the X-ray tube more than an induction-coil current of equal wave amplitude did. By cutting out all but the peak of the wave, however, the heat was reduced, and harder X-rays were produced than an ordinary transformer would yield. This cutting out had been effected by Dr. Morton by shortening the contact arcs. The portable apparatus exhibited, the first of British make, it was stated, resembled that of Dr. Coolidge (see Engineering, page 42 *ante*), and could be used for working any kind of X-ray tube. Mr. Burnside also showed how the heating current, of 4 amperes at 12 volts, for the kathode spiral of the tube was taken from an insulated portion of the transformer primary through a choking coil provided with an adjustable iron core. At the end of the lecture Captain Kaye announced that the first Silvanus Thompson memorial lecture would be delivered by Sir Ernest Rutherford on April 9. We should add that the membership of the Röntgen Society has rapidly been growing of late.

THE NAPIER BAND SAW MACHINE.

CONSTRUCTED BY THE NAPIER SAW WORKS, INC., SPRINGFIELD, MASS., U.S.A.

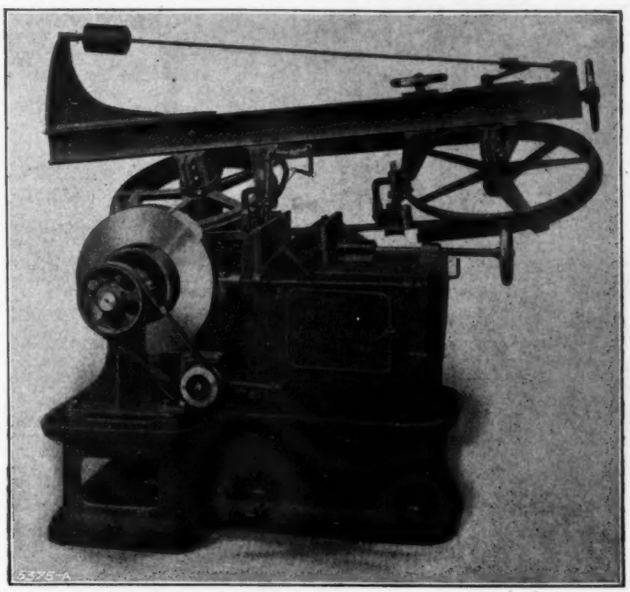


FIG. 1.

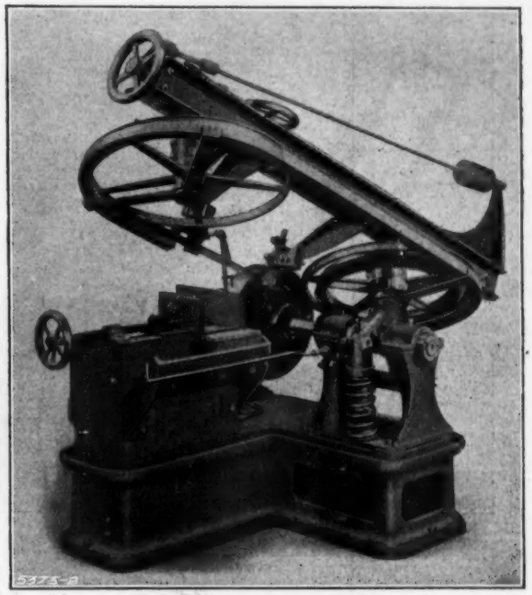


FIG. 2.

THE two illustrations above show one type of band sawing machine for metal constructed by the Napier Saw Works, Inc., of Springfield, Mass., U.S.A., and of Norfolk House, Laurence Pountney Hill, London, E.C. 4. Band saws for metal, of course, are not new, but this saw has many distinguishing features. The serrated band is carried on a tilting frame comprising two channel beams with cross-stays at each end, and a truss rod to prevent flexure. The weight of the frame furnishes the gravity feed, which can be adjusted to requirements by a balance weight. A spring at the front of the machine compensates for the angle of the frame, and keeps the feeding weight constant all through the cut. There are two guides for the saw blade, and these keep it perfectly vertical to ensure straight cutting.

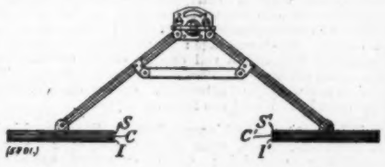
The machine is driven by a belt and clutch, the latter being built into the pulley, and it has also one change of speed, which is double that of the normal. The driving-band pulley is rotated by bevel gear, while the idle pulley can be adjusted to give the desired tension by means of a screw and hand wheel. Each band pulley is provided with a guard to protect the operator and to prevent the dripping of the cutting compound on the floor. The work is held in a powerful vice, and the whole is mounted on a heavy base of the cabinet type which encloses an oil tank.

The machine is made in several sizes. That illustrated will cut bars 10 in. by 10 in., with a saw 12 ft. 3 in. long, 1 in. wide, and 0.032 in. thick. In other machines the saws vary in width from ¼ in. to 1 in., and in thickness from 0.022 in. to 0.032 in. It is stated that these saws will cut off a 3-in. round bar of machinery steel in less than 2 minutes.

SEARCHING FOR BURIED SHELLS.

IN the early days of the Hughes' induction balance the hope was expressed that the balance would assist the miner in prospecting for certain ores, and would also help the surgeon in localising particles of iron that had become embedded in the human body. The advent of the Röntgen rays limited the latter application, and the difficulties of the former proved greater than was anticipated. We are afraid that the new particular utilisation of the balance in the search for projectiles which have penetrated into the earth will also find its limitations, although a certain amount of success has been obtained. It occurred to Professor Gutton, of Nancy, and Mr. Chanoit, an engineer, to make use of a portable induction balance in spotting live shells, and they devised an apparatus for this purpose, which they call "alpha." We are indebted to the *Génie Civil* of November 10 for our diagram and the particulars of this alpha apparatus.

The problem was simply to devise a suitable portable instrument, and it may probably be solved in other ways. The alpha consists of a pair of primary and secondary coils, so combined with a telephone and a "hummer" or vibrator that, when the one primary comes near a mass of iron, a sound is heard in the telephone, whilst the telephone will remain silent when the two primary circuits are exactly in the same condition. As the symmetry will rarely be perfect, a regulator is added to the instrument by means of which balance is established each time before use. The two pairs of coils are wound on two wooden discs, C and C^1, 60 cm. in diameter; the I and I^1 are the two primaries which in the application of the instrument are lying flat on the ground, and S and S^1 are the two secondaries; the distance between the centres of the two discs is 1.5 m., about 5 ft. The jointed arms with which the coils are connected in the way the diagram



shows, are made of wood; at the apex is the wooden handle, of which the observer takes hold; the main weight of the instrument is, however, taken up by a strap which is carried over the shoulder. The regulating device mentioned is mounted at the apex. It consists of two small concentric coils; the outer one is inserted in the primary circuit; the inner coil, in the secondary circuit, can be turned, and the angle between the two coils can thus be varied between 0 deg. and 90 deg. The vibrator and the induction coil and battery of three cells which actuate the vibrator are placed in a box which is carried by the observer's assistant; a flexible conductor joints the two parts of the instrument. The weight of the alpha instrument is not mentioned, but the need of a second man suggests that it is not inconsiderable. In conducting his search the observer, followed by his assistant, walks over the ground, keeping the flat coils as near the ground as is advisable and listens in the telephone, having previously tuned the regulator to silence. It is stated that a shell of about 10 kg. weight is easily discovered by this test if buried to a depth of 40 cm. or 50 cm.; a hand bomb would betray itself if buried to a depth of 30 cm. The maximum depth stated is only 20 in., and that is not much. It is said that experiments are proceeding for enlarging the range of the instrument, and some improvement may be expected. It must be borne in mind, however, that the balance is a differential instrument, and that with greater depths and greater masses of iron the differential effect on the two coils would be diminished; the coils and their distance apart would thus have to be enlarged, and the portability of the instrument would suffer. On the other hand, live shells are dangerous objects, especially to the farmer. Fortunately, his plough and spade do not, as a rule, go deep down into the earth.

COLOUR PHOTOGRAPHY.—Lecturing upon "The Chemical Action of Light" in the Royal Institution, on the two last Saturdays of January, Professor W. J. Pope, F.R.S., of Cambridge, president of the Chemical Society, distinguished between the direct, though sometimes slow effects—like the tanning of the skin, the decomposition of the colourless vapours of chlorine peroxide, which the beam of a lamp quickly turns into a dense cloud, the darkening of the white cuprous chloride and of iron salts (ferric oxalate or citrate)—and the more indirect instantaneous effects on gelatine impregnated with bichromate solution and on silver salts, which have to be brought out by developers. The lecturer then turned to colour photography, on which he had lectured three years ago (see ENGINEERING, March 13, 1915, page 304), and was able to illustrate the remarkable progress achieved in this art by exhibiting photographs of flowers, butterflies (displaying the metallic iridescence) and of rock sections taken in polarised light, a special study of the lecturer's. Progress was mainly due to the improvement in sensitisers and in colour screens. The modern sensitisers made the whole spectrum sensitive so that the plate was impressed by the different colours almost like the human eye; and the screens of dots of three colours (yellow-red, green, blue) or of starch grains of these colours were so fine that the difficulties of the early coarse lines in three colours were overcome. There remained technical difficulties, especially with kinematograph films, however. The kinematograph films were very small, 1¼ in. by 1 in. Three pictures might be taken—instead of three identical pictures—the first through a red screen, the second through a green, the third through a blue screen, and the negatives afterwards projected through red, green and blue screens again. To blend these colour impressions in the eye, however, the pictures would have to be worked at the rate of 45 or 50 pictures per second, whilst the practical rate of working was 17 pictures per second; the delicate films would not stand much more rapid rates. A compromise had, however, been obtained with two-colour screens, bluish-green and red; fair colour effects were realised when working at a rate of 30 pictures per second. Considerable progress had also been achieved in air photography taken from aircraft on sensitised plates; but those matters could not be discussed at present. One striking feature to which Professor Pope drew attention was the pseudo-stereoscopic effect of ordinary coloured photographs; the objects seemed to stand out in relief, more than on black and white photographs, probably because the eye was differently focussed for different colours.

U-FRAME JACKTRUCK AND ELEVATOR.

CONSTRUCTED BY MESSRS. JOHN T. HARDAKER, LIMITED, ENGINEERS, BRADFORD.

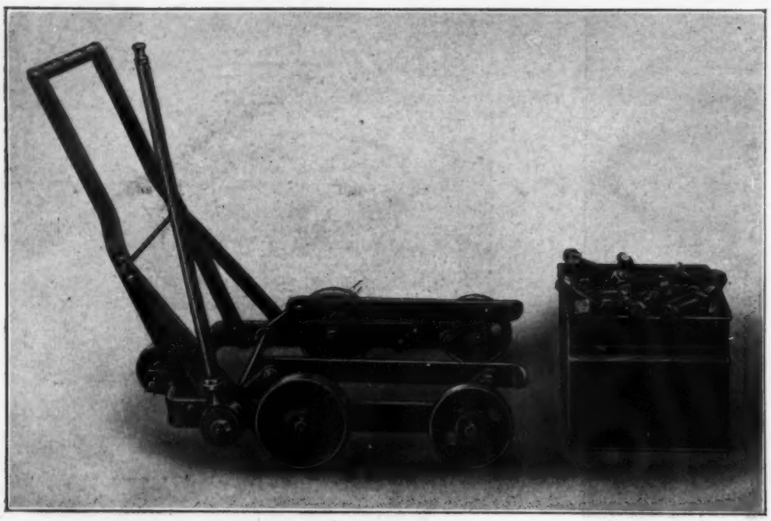


FIG. 1

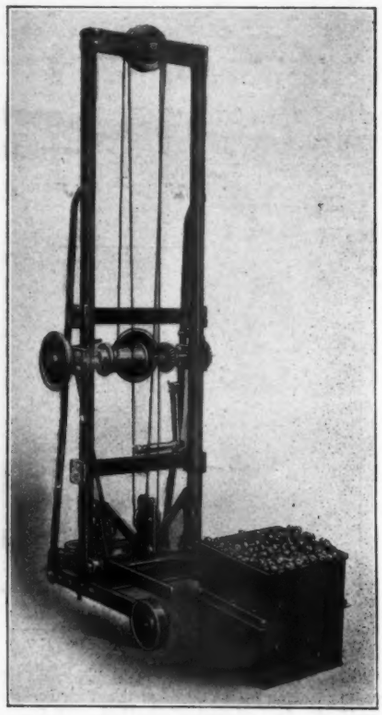


FIG. 2.

IN the course of one of our recent articles dealing with the arrangement of machine shops (see ENGINEERING, vol. civ, page 192), we gave an illustrated description of several types of shop transport trucks built by Messrs. J. T. Hardaker, Limited, Bowling Iron Works, Bradford. We illustrate on the present page, in Figs. 1 and 2, the Hardaker 1918 model U-frame jacktruck, and the Hardaker 1918 model U-frame elevator. The truck, Fig. 1, is all metal; it has four wheels, two on each side, fitted with roller bearings, and a back wheel. It can turn round either way in its own length. The four wheels being outside the frame, the truck is suitable for carrying a large amount of small articles packed in a deep box, shown in Fig. 1. It can be built to suit boxes up to 2 ft. wide. The boxes can be supplied to given weights and being tared, the number of articles they contain can be arrived at without counting them. The lever, which is on the side in the type we now illustrate, serves to raise the truck platform with its load and to deposit it where needed. For hoisting a box containing a series of mechanical parts where these are required, Messrs. Hardaker build the elevator we illustrate in the view Fig. 2. This elevator is operated by hand, the device consisting of a thin wire rope transmission running on return pulleys and winding round a small drum. The platform can be locked at any given height by acting on a hand lever.

CATALOGUES.

Roller Bearings.—A booklet giving arguments in favour of the Hyatt flexible roller bearing has been issued by Messrs. Broom and Wade, Limited, High Wycombe, the makers of this bearing. The roller is, in effect, a spring coil made of square section steel. It gives some elasticity under shock, is adaptable lengthwise to unevenness in the races, and the slight opening between the spirals helps lubrication.

Electrical Machinery.—Messrs. Vickers, Limited, Broadway, London, S.W. 1, send a book of over 50 pages of illustrations of electrical machinery with titles and short descriptive paragraphs in English, French, Italian and Spanish. The views include erecting and testing workshops, alternating current and direct-current generating plant, rotary converters and motor generators, a large variety of motors and a number of heavy machines fitted with motor drives, including variable speeds and reverses.

Electric Switch Gear.—The British Thomson-Houston Company, Limited, Rugby, send a special catalogue describing their truck-type of ironclad switch gear for polyphase systems up to 11,000 volts. The switch gear unit for each circuit is mounted complete in a frame on four truck wheels, so that it may be placed in line with others making a general switchboard or removed for repairs or isolated service. The special object of the design is to promote safety and to facilitate inspection and repairs with the least general stoppage.

Tramway Points.—An interesting history of the progress of tramway point-making is set out in a book issued by Messrs. Edgar Allen and Co., Limited, of Sheffield. Within thirty years practice has passed from the cheapest and poorest metals to the finest metal that can be made for the purpose. Practically all important work is now done on manganese steel which is highest in first cost and most economical in use. Illustrations are given of the design, pattern-making, moulding, casting, grinding and finishing processes. The book includes a reprint of Mr. Fred. Bland's paper on "Thirty Years of Tramway Practice," read at a meeting of the Tramway Association.

Salt Detector for Boilers.—The usual salinometer test is a test of the water in the boiler at a particular moment. An instrument which would give a continuous indication of salt in the feed-water would be useful, especially as such things are generally capable of giving an alarm. The Bromell Patents Company, Limited, 62, Robertson-street, Glasgow, send a catalogue describing an instrument of this kind which they are making. A portion of the feed water passes continually through the instrument and in the path of an electric current, which also passes through an incandescent lamp. The lamp will not glow as long as the water is pure, but a little salt in the water so quickly lowers the electrical resistance that a dull red glow will appear, and increase to full brightness with a heavy percentage of salt. The sensitiveness can be varied simply by using lamps of different candle-power: a warning is fitted to sound at a certain salt-percentage: a recording voltmeter can be added to mark a roll or dial chart, and as low as one grain of salt per gallon can be readily shown. These claims are worthy of attention. One of the instruments has been in constant use for over a year.

Refrigerating Machinery.—Messrs. Seagers, Limited, of Dartford, Kent, send a catalogue of refrigerating machinery containing some excellent explanatory matter and full particulars on all practical points. A very wide range of machines is made, marine and land types, with direct steam or electric drive or for belt drive. The icemaking capacity per day (24 hours) ranges from 4 cwt. to 65 tons. A complete marine plant for making 23 cwt. per day weighs 2¼ tons and uses 4½ h.p. Four tons per day requires 11 h.p. and larger quantities about 2 h.p. for each additional ton. All the cooling is done by work on CO_2. Messrs. Seager have introduced a new stage in the process by which the gas passes through an additional vessel in each cycle and the gases from different receivers are taken in by the compressor in a particular order. The matter is fully explained in the catalogue. The effect is an increase of 25 per cent. to 100 per cent. in cooling power at an increased cost of 15 per cent. to 50 per cent. in motive power. The economy is highest where the cooling water is warmest. The mechanism of this new stage may be fitted into existing plants. All parts of the system liable to wear or accident are dealt with separately in the catalogue and can be supplied separately.

Milling Machine for Profiles.—A booklet describing the methods of setting up and working their profile-milling machines has been issued by Messrs. Webster and Bennett, Limited, Coventry. These machines are horizontal and duplex: on a standard similar to lathe shears and 7 ft. long, are mounted two pairs of heads, each pair being independent in its working. The cutter rotates in a fixed headstock, which has its own belt drive. The second headstock carries the work-piece and has the motions of a compound slide rest and also a rotary motion, and a copying or former motion, and is driven by a separate belt. The work-piece is attached to a faceplate, the edge of which is cut as a master cam to give the copying motion to the sliding head. The work-piece, therefore, revolves slowly against the rotating milling cutter, and in the course of each revolution is carried to and from the cutter, in obedience to the master cam. A revolution (or such part of a revolution as the job requires) of the work-piece (with the master cam) completes a cut, and several cuts may be taken if required. The work-piece is automatically drawn away from the cutter at the end of each cut. Profile or irregular shapes may be cut on the circumference, bore or face of the work-piece. Master cams are cut on the machine itself and are copied from a specially-made template or sample work-piece. The machine cuts a great variety of shapes which might otherwise require a number of machinings or have to be made in several parts and fixed together. Four standard machines are made; One duplex with centres 6½ in. above the bed and a three-step belt drive: a second with similar measurements, but a single pulley and gear drive: a third, similar, but with gaps in the bed to swing-connecting rods and similar pieces: the fourth is a single machine for milling camshafts up to 44 in. long with integral cams.

Large Lathes.—"The big lathe" is well represented in a special catalogue that comes from Messrs. G. and A. Harvey, Limited, Govan, Glasgow. Illustrations and specifications are given of 14 of these monster machines. Four shafting lathes are made for constant-speed motor or single-pulley belt drive with centres 18 in., 21 in., 24 in. and 30 in. above the bed surface, and taking 23 ft. to 25 ft. 6 in. between centres. There are four similar lathes for either variable speed motor or cone-belt drives, with centres 21 in. 24 in., 30 in. and 36 in. high, and two for variable-speed motor drive only with 48-in. and 60-in. centres. Two facing lathes are made to swing jobs of 6 ft. and 7 ft. 5 in. diameter. All the foregoing have flush beds, and there is one gap lathe to swing 5 ft. in the gap and 4 ft. over the bed. All these are for high-speed cutting: the number of speeds vary over 12, 24 and 30, the revolutions per minute vary from seven-tenths of one up to less than two as minima and from 27 to 70 as maxima. The feeds are four, six or eight in number, and all except the facing lathes have two slide rests and leading screws of 1 in. pitch. In total net weight the lightest is the gap lathe at 20 tons, and the heaviest lathe weighs over 82 tons. The front journal of the largest lathe spindle is 15 in. in diameter and 19 in. long. Every convenience is fitted for easy and rapid handling of slide rests, loose headstock, feeds and speeds: practically nothing being beyond the comfortable reach and hand-power of a workman of ordinary build.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

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Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

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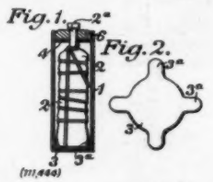
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

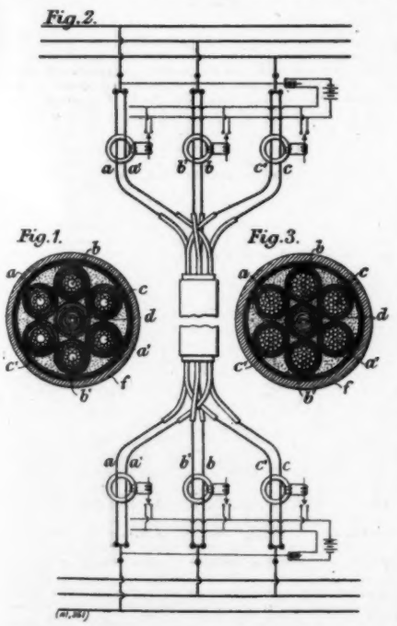
ELECTRICAL APPARATUS.

111,444. The Edison Swan Electric Company, Limited, Ponders End, and S. S. Bird, Bush Hill Park, Enfield. Electric Batteries. (6 *Figs.*) July 12, 1917.—This invention relates to dry batteries for electric torches. 1 designates the zinc outer casing or negative and 2 designates the "dolly" which rests upon the bottom washer 3, which is made from leather board. The carbon rod positive element 2a of the "dolly"



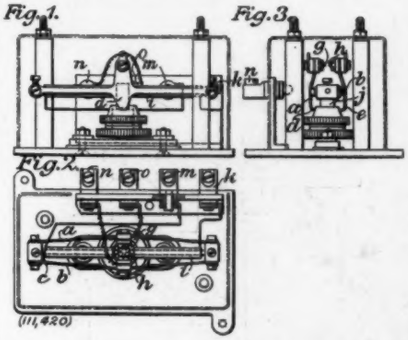
protrudes through the usual top centralising washer 4, and its extremity, which is provided with a metal conductor cap, projects above the usual filling 6 of pitch. The washer 3 is essentially so formed as to embrace the bottom of the "dolly" and centralise the latter, and this may be accomplished by stamping the washer blanks 3 with a suitable number of lugs or projections 3a. (*Accepted December* 5, 1917.)

111,351. Electrical Improvements, Limited, Newcastle-on-Tyne, Callender's Cable and Construction Company, Limited, and J. O. Callender, London. Electric Supply Systems. (3 *Figs.*) November 30, 1916.—This invention relates to the protection of electric supply systems in which split or parallel conductors are employed. According to the present invention, there is employed in combination with apparatus acting to cut out a faulty conductor when the balance of currents in the companion conductors of a pair is upset, a multicore cable comprising two or more insulated cores forming paired or com-



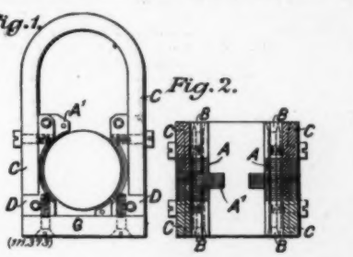
panion conductors, the cores of each pair being at opposite ends to a diameter of the cable and separated from each other by a central dummy core. *d* is the dummy core, *a* and *a1* are two insulated conductors of a pair and of one phase, *b* and *b1* are two other insulated conductors of another pair and of a second phase, and *c* and *c1* are another pair of insulated conductors and of the third phase. All the conductors are similarly insulated and each conductor of a pair has a conductor of a different pair adjacent to it on each side, and is separated from its companion conductor by the dummy core *d*. *f* is a sheath such as is ordinarily used in cables. (*Accepted December* 5, 1917.)

111,420. E. A. Graham, and W. J. Rickets, Brockley. Thermal Electric Relays. (4 *Figs.*) April 16, 1917.—In thermostatic apparatus according to this invention, electric contacts are carried by lever members connected to or forming part of the obtuse angular sides of a quadrilateral frame and are fulcrummed at their ends remote from those carrying the contacts, so that upon extension of the frame by the relative expansion by heating or cooling of a diagonal member connected to the acute angular ends of the frame, and consequent flattening of the obtuse angular sides of the frame, the end portions of the lever members carrying the contacts will be caused to move laterally to a greater extent than the obtuse angular side portions of the frame. *a* and *b* are two bent flat metal spring members connected together to form a frame in the shape of a parallelogram having equal sides, and *c* is an expansible member, forming a diagonal and connecting the two acute angles of the frame. At the middle part the members *a*, *b*, that is to say, at the obtuse angles of the parallelogram, are respectively formed with or rigidly connected to two levers members *d* and *e*, which extend across them. The lower ends of these lever members bear upon or against opposite sides of a vertically-adjustable abutment which may be in the form of a truncated cone. The opposite or upper extremities of the lever members *d* and *e* carry the insulated contacts *g* and *h* by which the relayed or



controlled circuit is to be completed. The expansible diagonal element *c* is wound with an insulated resistance *i*, which carries the controlling current. The ends of the resistance *i* are connected to terminals *k* and *m*, and the contacts *g* and *h* to terminals *n* and *o*. The action of the apparatus is as follows: The controlling current passing through the resistance *i* heats the expansible diagonal member *c*, which expands and causes a shrinkage of the opposite diagonal of the parallelogram. This causes the central points of the lever members *d* and *e* to be moved towards each other, their lower extremities acting against opposite sides of the fixed abutment which serve as fulcrums. An increased movement is thus given to the upper ends of the lever members carrying the insulated contacts *g* and *h*, which are caused to co-act to complete a relay or other circuit. In producing this movement, the side members *a* and *b* of the frame are slightly bent, and at the same time are slightly twisted. (*Accepted December* 5, 1917.)

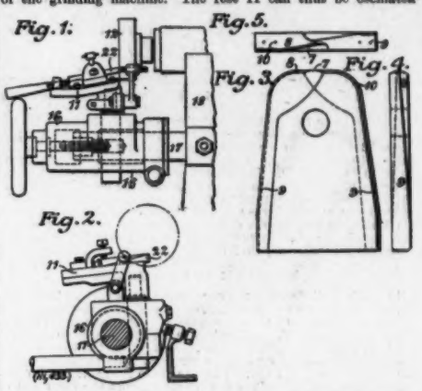
111,373. The M-L Magneto Syndicate, Limited, G. A. Lister and E. A. Watson, West Orchard, Coventry. Magneto-Electric Machines. (2 *Figs.*) January 4, 1917.—This invention relates to magneto-electric machines such as are used for ignition purposes on internal combustion engines. According to this invention, the magneto-electric machine is characterised by pole shoes formed of laminated plates disposed in planes at a right angle to the axis of the armature, with or without a solid



block at each end of the bundle of laminations, and provided with a rearward step to engage the end of the magnet limb. A are laminated plates (some of which are extended if required at A1) and B are solid blocks. C are the limbs of a permanent magnet, and D is a rearward step on each pole shoe adapted to engage the end of the magnet limb. The laminations are held together by rivets and screws secure the magnet and shoes to a baseplate G. The shoes are connected to the limbs of the permanent magnet by screws. (*Accepted December* 5, 1917.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

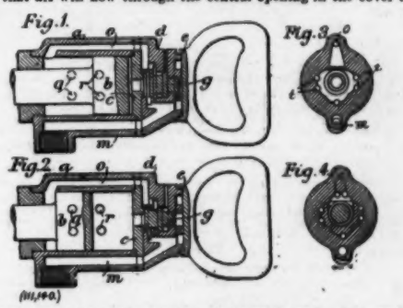
111,433. T. Lumsden, Gateshead. Tool-Grinding Machines. (6 *Figs.*) May 16, 1917.—This invention relates to tool-grinding machines and provides improved means for "cross-pointing" and "blending" the cutting edges of "spade" and the like cutters. According to the present invention, a tool-grinding machine is provided with an attachment comprising a tool rest so mounted that it can be oscillated about two axes, one at right angles to the grinding surface of the grinding wheel or disc and the other parallel with said surface, the surface of said tool rest whereon the cutter is secured being inclined in two directions, the angles of inclination being equal to the angles of the cutting edges of the cutter. Referring first to Figs. 3, 4 and 5, it will be seen that the two cutting edges of the spade cutter meet at 7. The process of "cross-pointing" consists in grinding the top edges 8 of the cutter so that they are inclined to a line vertical to the flat face of the cutter. The two cutting edges are oppositely inclined. It is standard practice to form the side portions 9 of the cutting edges of the cutter so that they are inclined at an angle of 4 deg. to a line vertical to the flat face of the cutter, while the top portions 8 of the cutting edges are formed so that they are inclined at an angle of 8 deg. to a similar vertical line. The process of "blending" consists in forming a smooth curve at the corners 10 to unite the two portions 8 and 9 of the cutting edges. Referring now to Figs. 1 and 2, the attachment comprises a tool rest 11, the top surface of which is inclined in two directions, the inclination to a horizontal line at right angles to the grinding surface 12 of the grinding disc 13 being 8 deg. (Fig. 1), while the inclination to a horizontal line parallel with the surface 12 is 4 deg. Fig. 2). The rest 11 is supported by a boss mounted on and free to oscillate about a vertical pivot carried by a barrel 16 mounted on and free to oscillate about a horizontal pivot 17 carried by the frame 18 of the grinding machine. The rest 11 can thus be oscillated



about a vertical axis (*i.e.*, an axis parallel with the grinding surface 12), or about a horizontal axis (*i.e.*, an axis at right angles to the grinding surface 12). The spade cutter 22 to be "cross pointed" and "blended" is secured on the upper surface of the tool rest 11. (*Accepted December* 5, 1917.)

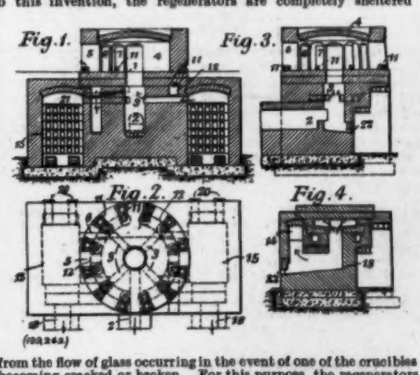
MINING, METALLURGY AND METAL WORKING

111,140. R. De H. St. Stephens, Camborne, and Climax Rock-Drill and Engineering Works, Limited, Carn Brea. Percussion Rock Drills. (7 *Figs.*) November 11, 1916.—This invention relates to valve gear for percussion rock drills. *a* indicates the working cylinder, *b* the percussion piston and *c* the plate forming the rear end of the cylinder and having a central port or opening. *d* indicates the valve-chest, and *e* the rear cover, between which and the plate *c* the said valve chest *d* is clamped. *g* indicates the valve having parts of different diameter, the larger part or head having formed in it a peripheral groove so as to form two collars. *m* is the air-supply passage. *o* is a passage establishing communication between the valve chest and the front end of the cylinder *a*. The ports through which the passages *m*, *o*, communicate with the valve cavity are so located that when the valve is in the position shown in Fig. 1, the front collar of the valve lies between the ports so that air will flow through the central opening in the cover *e*



into the rear end of the cylinder *a* to drive the piston *b* forward, whilst when the valve is in the forward position the ports are connected by the peripheral groove of the valve so that live air can pass to the front end of the cylinder *a*. *q*, *r* are exhaust openings in the cylinder wall, the openings *q* serving for the exhaust from the front end of the cylinder during the forward movement of the piston *b*, and the openings *r* for the exhaust from the back end of the cylinder. In both cases these exhaust openings are placed in such positions that a certain amount of air will be imprisoned before the piston's stroke is complete, such imprisoned air in front of the piston serving to cushion the latter, whilst the air at the rear of the piston serves not only as a cushion but also to move the valve rearwardly in well-known manner. It will thus be understood that the valve operates simply for controlling the admission of air alternately to the two ends of the cylinder, and in no way serves for controlling the exhaust. (*Accepted November* 28, 1917.)

109,243. Ch. M. Stein and Cie., Paris, France. Crucible Smelting Furnaces. (8 *Figs.*) August 29, 1916.—According to this invention, the regenerators are completely sheltered



from the flow of glass occurring in the event of one of the crucibles becoming cracked or broken. For this purpose, the regenerators are situated outside the main body of the furnace and protected from contact with the glass by a glass pit which permits the flow

of glass to take place in the hottest parts of the circulation of the flames, the waste flame accompanying the glass up to the outlet from the glass pits, thus keeping the glass in a state of fusion and preventing it from solidifying. The central burner protects the radial flues which conduct the hot air to the said burner. A gas generator delivers gas to the central burner 1 through the flue 2. The hot air, coming from the regenerators which burn the gas, is delivered to the central burner 1 through the radial flues 3. The flames then pass into the crucible chamber 4 through the hole in the central burner 1. This crucible chamber is formed of vaulted arches 5, 6, 7. Each arch takes a melting-pot of the ordinary type. The flames, after having heated up the crucibles, leave the crucible chamber 4 through the holes 11, and reach the semi-circular flues 12, whence they pass by the passages 13 and 14 to the regenerators 15, and then pass by the flues 18 to the chimney. The air is admitted to the regenerators 15 through the grids 20. It becomes heated and is delivered to the hot air chambers 21. To prevent the choking up of the passages by the glass which may escape from cracked or broken pots, the base of the central burner and of the flues are shaped to form glass pits, which are provided with plugs 22 (see Fig. 3 and 4) and permit the glass to run away to the outside of the furnace. (*Accepted November* 28, 1917.)

MOTOR ROAD VEHICLES.

111,242. Caterpillar Tractors, Limited, London. (*The Holt Manufacturing Company, Incorporated, Stockton, California, U.S.A.*). **Vehicles with Flexible Self-Laying Tracks.** (4 *Figs.*) April 30, 1917.—This invention relates to vehicles with flexible self-laying tracks. According to the present invention, the equalising beam is arranged upon the front end of the main frame and is secured at its ends to the front extremities of the truck frames. Thus the trucks support the front end of the main frame. A main frame 10 is supported at each side upon a roller truck mechanism, comprising a longitudinal truck frame 11 having a forward extension 12 terminating in line with the extreme front end of the main frame and near its rear end, a series of flanged rollers 13 which operate upon an endless, flexible track 14, the latter running around a rear driving sprocket

Fig. 1.

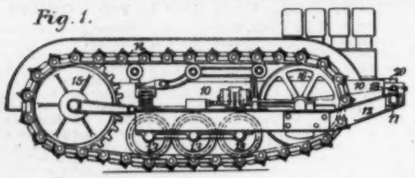
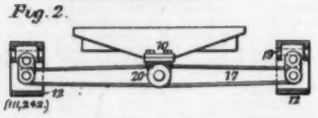


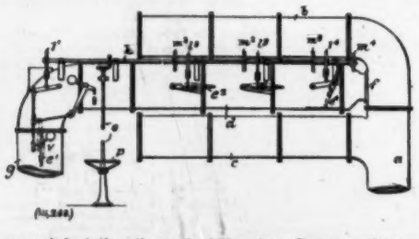
Fig. 2.



wheel 15 journalled directly upon the main frame and an idler wheel 16, journalled upon the truck frame 11. The front ends of the extensions 12 are joined by an equaliser bar 17, which has pendant links connecting with said extension by means of gimbal joints 19. Bearing centrally upon the equaliser bar is a bifurcated member 20, pivotally connected thereto, said member being secured to the front end of the main frame and constituting the sole support for this portion of the frame. The rear end of each truck frame carries a compressible helical spring 22, upon which rests the rear end of the main frame. Thus there are two supports, one at either side for the rear of the main frame, which, with the single support at the front, constitute a three-point suspension capable of great flexibility. (*Accepted November* 28, 1917.)

PUMPS.

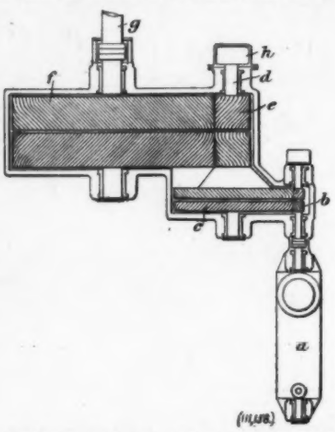
111,260. T. Mohn, Levenshulme, Manchester, and The National Gas Engine Company, Limited, Ashton-under-Lyne. Air Compressors. (3 *Figs.*) July 10, 1917.—The present invention relates to reciprocating air compressors of the type in which valves are provided in the delivery pipe and in the cylinders for by-passing the air from one or more of the blowing cylinders. The invention consists in providing valves in the delivery pipe and in the cylinders so arranged that air from one, two or more of the blowing cylinders can be by-passed and passed back into the suction pipe, the valves being actuated from a single camshaft turned by a hand wheel, which can be rotated in one direction to operate the valves in the order required. The air passes from the suction main *a* to the two suction pipes *b*, *c*, from which it passes to the upper and lower ends of the blowing cylinders. From the blowing cylinders the air passes to the delivery pipe *d*. In the delivery pipe *d* there are provided four valves e^1, e^2, e^3, e^4, and the delivery pipe *d* leads back to the suction pipe at *f*, the delivery main *g* being



connected at the other end of the pipe. By-pass valves are provided on each of the blowing cylinders so that the air can pass from one side of the piston of the cylinder to the other through these valves. The valves e^1, e^2, e^3, e^4, are controlled through links and levers by cams l^1, l^2, l^3, l^4, on the shaft *k* which is fitted to the delivery pipe, while the by-pass valves are controlled by the cams m^1, m^2, m^3, m^4, on the same shaft. The shaft *k* is rotated by the vertical shaft *o* and hand wheel *p*. For starting, the hand wheel is moved to the position in which all the valves are open except the valve e^1. Air is thus delivered back into the suction main *a* at practically atmospheric pressure, and can by-pass the piston of each cylinder. The second position is that in which two cylinders are delivering to the delivery main. In this case the valve e^1, between the blower and the delivery main, is open and the valve e^2 is closed, the valves e^3 and e^4 remaining open. At the same time two of the by-pass valves are closed and two are open. With the valves in this position cylinders 1 and 2 deliver air under pressure to the delivery main, while cylinders 3 and 4 deliver air against atmospheric pressure to the suction pipe. In the next position the valve e^2 is opened and the valve e^3 is closed. In this case cylinders 1, 2 and 3 deliver air to the delivery main, while cylinder 4 delivers air to the suction main. In the fourth position of the hand wheel, in which all cylinders are delivering air, the valve e^3 is opened and the valve e^4, between the delivery pipe and suction main, is closed, the by-pass valves being also all closed. (*Accepted November* 28, 1917.)

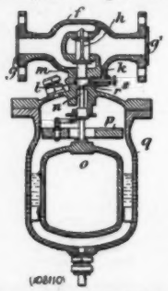
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

111,158. The Hon. Sir C. A. Parsons, S. S. Cook and E. B. Chapman, Newcastle-on-Tyne. Turbine-Gear Trains. (6 *Figs.*) November 16, 1916.—The invention relates to gear trains and consists in employing a balance weight on the intermediate shaft so arranged that the centre of gravity of the shaft taken as a whole substantially coincides with the point at which the resultant of the other vertical forces acting



on the shaft crosses the axis. The power unit *a* is provided with a double-helical pinion *b* driving the double-helical gear wheel *c* on the intermediate shaft *d*. The intermediate shaft also carries a double-helical pinion *e*, which drives the gear wheel *f* on the driven shaft *g*. A balance weight A is placed at the end of the intermediate shaft *d* remote from the wheel *c*. (*Accepted November* 28, 1917.)

103,110. Societe J. and A. Niclausse, Paris, France. Feed-Water Regulators. (2 *Figs.*) January 3, 1916.—This invention relates to an automatic feed-water regulator of the type in which there is an unbalanced valve controlled by a piston and a balanced float valve provided with a needle valve which opens or closes an orifice in the piston chamber, the passage of water to said chamber being adjusted by a valve. According to this invention, the needle valve is arranged to open or to close an orifice at the bottom of the piston chamber, thus providing a regulator in a very compact form, and the unbalanced valve is formed with a double seat. The feed water from a pump or injector passes through the shell *j* of the regulator, the pipe *g* communicating with the boiler and the pipe g^1 with the feed apparatus. The double-acting unbalanced valve A prevents the passage of water when the water is above the predetermined level chosen, but allows the passage of water when this level is not attained. When the vaporization is exactly equal to the feed the valve remains in equilibrium in the open position. As the lower seating of the valve is larger than its upper seating, the pressure of the feed water, which is greater than the pressure from the boiler, constantly tends to open the valve A. It cannot,



however, open by reason of the pressure of water which, entering through the feed pipe, passes into the passage *k*, fills the chamber *l* and raises the piston *m* which carries the valve A. The orifice *r* at the bottom of the chamber *l* is closed by the needle valve *n*, which is carried at the top of the cylindrical float *o*. The forces which tend to lower the valve *n* are the downward thrust due to the feed water, and its own weight added to that of the float *o*, and these are counterbalanced by the action of the counterweight *p* and by the action of the water upon the float *o*. If the level of the water falls in the boiler, and consequently in the chamber *q*, the action of the water upon the float becomes less and the valve *n* opens the chamber *l*; this empties more quickly than it can be filled through the passage *k*, the valve *h* falls and allows the passage of feed water. As soon as the level of water rises to the predetermined level, the valve *n* is raised by the float *o*, and closes the orifice *r*; the valve A also is thereupon raised by the pressure of the feed water and closes. The passage *k* is provided with a valve *s* which, on being rotated by hand, is moved so to close the inlet of feed water into the chamber more or less. (*Sealed.*)

TEXTILE MACHINERY.

111,267. Lister and Co., Limited, W. H. Watson, and W. T. Marshall, Bradford. Twisting and Winding Yarn. (2 *Figs.*) December 13, 1916.—This invention relates to machines for twisting and winding yarn in the process of curling the same. According to this invention, the machine is so arranged that the yarn, after being twisted, is wound upon positively-driven bobbins. The yarn from the dressing machine passes in the form of string to let-off rolls, 15, 15, tweedlers 16, and take-off rolls 17, 17. From the take-off rolls 17, 17, it passes over pulleys 18 to the eyelets 19 of the flyers 20 of bobbins 21, upon which it is wound. The tweedlers 16 and the take-off rolls 17, 17, are driven in the following manner: 22 is the main shaft of the machine, upon which is a bevel wheel 23 gearing with a bevel wheel 24 on a vertical shaft 25, upon whose other end is another bevel wheel 26 gearing with a bevel wheel 27 on a countershaft 28. A hollow shaft to which the tweedler 16 and take-off rolls 17, 17, are fixed, is driven from the shaft 28 through skew gear 30, and upon the hollow shaft is a pinion 31 meshing with a pinion 32 on a stud axle 33, on which is a second pinion 34 meshing with a pinion 35, which is loose on the shaft 29 and has on it a bevel wheel 36 meshing with another bevel wheel 37 fast on the spindle of one of the take-off rolls 17, as seen in Fig. 2. Each bobbin 21

Fig. 2.

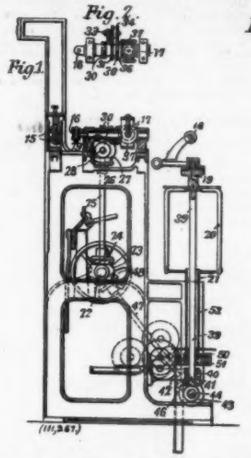
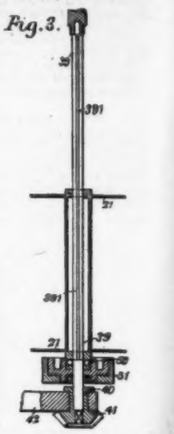
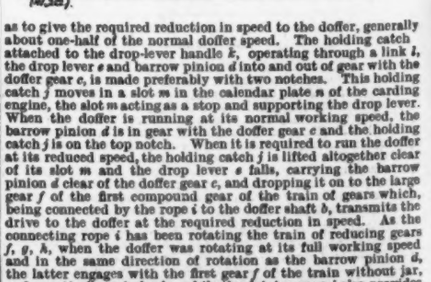


Fig. 3.



is mounted upon a spindle 39 having a feather 391, so that the bobbin is rotated with the spindle, but is free to slide upon it. The end of each spindle 39 is supported in a bush 40 formed in one with a bevel wheel 41, the bush being carried by a bracket 42. The bevel wheel 41 gears with another bevel wheel 43 upon a countershaft 44. On the countershaft 44 is a bevel wheel 45 in gear with a bevel wheel 46 on an inclined shaft 47, having at its other end a bevel wheel 48 gearing with a bevel wheel 49 on the main shaft. All the bobbins 21 are supported by ball bearings 50 (see Fig. 3) on a carriage 51, which extends the whole width of the machine and is capable of moving vertically up and down between guides 52 at each side of the machine. The carriage 51 is given the vertical up-and-down motion by means of mechanism at each side of the machine driven by worms on the shaft 44. (*Accepted November* 28, 1917.)

111,212. W. Muir, Heaton Chapel, Stockport. Carding Engines. (1 *Fig.*) February 9, 1917.—The invention relates to an improved arrangement for driving the doffer when required at a speed slower than its usual working speed. A grooved rope pulley *a* is mounted on the doffer shaft *b*, on the same side of the engine as and next to the doffer gear *c*, which is driven by the barrow pinion *d* in the usual manner to impart the normal working speed to the doffer. The barrow pinion is a compound gear, and its large spur wheel d^1 receives its motion from a gear *x* fixed on the boss of a rope pulley *y* which is mounted on the boss of the drop lever *e* and is driven from the pulley on the main cylinder shaft of the carding engine. Beneath the drop lever *e* which carries the barrow pinion *d*, a train of gears is mounted, the first gear of which is directly underneath the barrow pinion. This first gear *f*, f^1, is a compound gear, and the smaller gear f^1, when the larger gear *f* is in mesh with the barrow pinion *d* for the slow speed, drives an intermediate compound gear *g*, g^1, which, in turn, drives a gear h^1 compounded with a grooved rope pulley *h* connected by means of an open rope *i* to the grooved rope pulley *a* on the doffer shaft *b*. The ratio of the gears and pulleys is such



as to give the required reduction in speed to the doffer, generally about one-half of the normal doffer speed. The holding catch *j* attached to the drop-lever handle *k*, operating through a link *l*, the drop lever *e* and barrow pinion *d* into and out of gear with the doffer gear *c*, is made preferably with two notches. This holding catch *j* moves in a slot *m* in the calendar plate *n* of the carding engine, the slot *m* acting as a stop and supporting the drop lever. When the doffer is running at its normal working speed, the barrow pinion *d* is in gear with the doffer gear *c* and the holding catch *j* is on the top notch. When it is required to run the doffer at its reduced speed, the holding catch *j* is lifted altogether clear of its slot *m* and the drop lever *e* falls, carrying the barrow pinion *d* clear of the doffer gear *c*, and dropping it on to the large gear *f* of the first compound gear of the train of gears which, being connected by the rope *i* to the doffer shaft *b*, transmits the drive to the doffer at the required reduction in speed. As the connecting rope *i* has been rotating the train of reducing gears *f*, *g*, *h*, when the doffer was rotating at its full working speed and in the same direction of rotation as the barrow pinion *d*, the latter engages with the first gear *f* of the train without jar, and practically noiselessly, while the driving rope *i* also provides sufficient elasticity to ensure the change being easy and without shock to the gearing. (*Accepted November* 28, 1917.)